An Analysis of Pretrial Detention and Turnarounds in the Cook County Jail

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At any given time, about 7,000 people are detained in jail and 2,500 people on Electronic Monitoring (EM) in Cook County. The majority of these detainees are awaiting trial, but delays in the court system extend their cases. These delays are significant—cases commonly extend a year or more. In the extreme, detainees can be incarcerated longer pretrial than their sentence would eventually require. The excess 675 years of detention time from these detainees cost Cook County over $35 million in housing costs per year. We develop a model of detainee behavior that affects their case lengths, and hence, the duration of their pretrial duration. Taking it to the data obtained from the Cook County Sheriff’s Office, we estimate detainees’ perceived costs of being detained in jail, prison, and on EM. Using these estimates, we consider four counterfactual interventions and study their impact. First, we consider operational improvements to court processes that may lower the number of court visits by the detainees. We find that removing one court visit from detainees’ cases can save the jail over $20 million in housing costs per year and reduce turnarounds by 10.9%. Second, we consider paying the bonds of detainees with lower level charges. We find that simple fund-allocation policies can reduce the pretrial jail population by 2%. Conservatively, this can save taxpayers four times what is paid toward bail. Third, we consider an alternative sentencing policy called split sentencing. By splitting sentences between incarceration and supervision or probation, the jail could save save $8.5 million in detention costs and remove over 2,900 visits to the Cook County courts per year. Finally, we consider remedies that can lower perceived costs of being detained in prison. We find that this can shorten case lengths by 193 years annually, remove 2523 court visits each year, and cut turnarounds by over 40%.

Key words: Criminal Justice, Pretrial Detention, Structural Estimation

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1. Introduction

In his award-winning book Courtroom 302, Bogira (2005) documents the bleak, everyday events of a Chicago courthouse. Illustrating the overburdened court system, he tells the story of Amy Campanelli: Amy Campanelli loves criminal defense work, but she’s burned out by the caseload of a courtroom public defender. So early in 1998 the ten-year veteran decides to quit.
Fifty cases would be manageable, she says in her office on a February afternoon, as she packs boxes on her final day at work, but she had more than a hundred... So she had to repeatedly ask for continuances. (p. 124)

At any given time, there are about 7,000 people detained in the Cook County Jail and 2,500 people on Electronic Monitoring (EM). The vast majority are detained pretrial, presumed innocent of their charges. But as with Amy Campanelli’s clients, these defendants’ cases are repeatedly continued; tabled month-by-month while an overloaded court system slowly processes them.

Cases begin when a person is first detained and continue while the courts work to determine their guilt or innocence. This can be time consuming: evidence must be discovered and shared between the prosecution and defense, administrative motions must be filed and processed, and arguments must be developed by both sides regarding the disposition of the detainee. When a court visit is scheduled but adjudication isn’t complete, the case is continued until a future date. Ostensibly, cases end with a trial when this fact-finding portion of the case is complete. But in practice, over 95% of cases end in plea bargains (Foxx 2018). By accepting a plea, detainees waive their right to trial in return for negotiated concessions from the prosecutor. If the defendant is found guilty, any time they spent detained in jail or on EM counts toward their sentence duration. If they are found not guilty, they are let free; any time incarcerated pretrial was wasted. Of course, regardless of the verdict, locking up defendants cost the tax payers. The Board of Commissioners of Cook County (2021) estimate that it costs $143 per day on average to hold a detainee in jail.

It isn’t uncommon for cases to endure longer than a year (see Figure 1a). In the extreme, cases can take so long that the detainee is locked up in the jail longer pretrial than their sentence eventually requires. Deemed “turnarounds,” these detainees are brought to prison, are photographed, fingerprinted, and booked, and are immediately released. Compensated with one-way bus fare, they “turn around” from the state prison in Joliet, Illinois back to the city.¹ Within our data, in 2016, there were approximately 2,000 turnarounds released from the Cook County Jail to the state prison (the Illinois Department of Corrections (IDOC)). The excess time they spent incarcerated—their “dead days”—amounted to over 675 years, and cost Cook County over $35 million in housing costs.

In this paper, we consider policies designed to alleviate the delays that keep people detained pretrial. But to do so, we need to understand detainee behavior and the drivers of case lengths. Generally, longer cases become less likely as time goes on. But in some cases, such as in Figure 1b, there are conspicuous “spikes” in the detainees’ case length distribution which occur at common sentence durations. Is it possible that there is more to it than a simple congestion story? Perhaps some detainees are intentionally delaying their cases to spend less time at undesirable sentencing locations. For example, consider a detainee awaiting trial on EM: at home, able to work, and getting credit against an eventual prison sentence. It may be preferable for their case to continue while they are on EM so they spend less time in prison. Detainees have loose control over the balance of their time they spend in their pretrial location vs. their post-sentencing location. Because most detainees plea, they have a good signal of the sentence they will receive, and can accept the plea to end their case when they desire. Roughly speaking, by continuing their case, they reduce the time they spend in their post-sentencing location in favor of their current pretrial housing location. For example, the highlighted spikes in the case-length histograms in the bottom-right panel of Figure 5 in Section 4.3 for detainees on EM, who have class 3 or 4 felony charges or misdemeanor charges, are consistent with such behavior.

In Section 6, we develop a model of detainee behavior when detained pretrial, and use it to estimate the perceived costs of being detained on EM, in jail, and in prison. We then apply these cost estimates alongside data provided by the Cook County Sheriff’s Office (CCSO) to study the effects of four different sets of counterfactual changes: straightforward improvements to the case processing at the Cook County Courts, paying the bonds of detainees with low-level charges, split sentencing, and reducing the perceived cost of prison.

Straightforward improvements to the Cook County Court system could curtail unnecessary administrative court visits for detainees. We model these style of improvements as a reduction in the number
of court visits required to resolve detainees’ cases. We show that reducing the required number of court visits by one can reduce annual Cook County Jail housing costs by $20.1 million, turnarounds by 10.9%, and total case lengths by over 515 years each year. The reduction in case length also helps ameliorate some of the load of the Cook County courts system.

Detainees are held in jail pretrial if they can’t meet their bond conditions. Many people’s bonds are small—one or two hundred dollars—and yet they are detained pretrial for months. We show that for a wide range of bonds, it is less expensive to pay the detainees’ bonds than house them during their trial. We suggest a prioritization method for detainees who don’t pose a threat to society. This method is easy to implement and results in housing cost savings that are more than four times what it spends on paying for bonds. A yearly million-dollar investment, for example, could reduce the jail population by approximately 1.7%, and save Cook County roughly $4.5 million in annual housing costs.

Split sentencing divides detainees’ sentenced time between incarceration and release. It reduces the jail population by directly reducing sentence durations and reducing detainees’ incentives to delay. This results in significant reductions in EM, jail, and prison populations, saves money, and reduces the load on the courts. For example, splitting sentences by half would save 870 years of detainee sentence time each year, reduce annual housing costs from the jail by $8.5 million, and reduce number of court visits by 2903. This policy also impacts the turnaround population. Measured against their original sentences, splitting sentences by one half would reduce the turnarounds population by 12.6%. But precisely because detention time in detainees’ sentences is reduced, there would be an increase in “new turnarounds”: detainees whose case length is longer than their split sentence. We find that splitting sentences in half would nearly double new turnarounds, causing a new 946.7 years of dead days, when measured against the detainees new, shorter detention portion of their sentences. This suggests that while the policy would make both the jail and detainees better off, it should be paired with polices which reduce case lengths to avoid the creation of new turnarounds.

Finally, we study the impact of reducing detainees’ perceived cost of prison. By reducing its perceived cost to be equal to that of jail, case lengths would be reduced by 193 years each year, there would be 2523 fewer court visits each year. Turnarounds would be reduced by 41.5%, and the detainees would have 63 fewer years worth of dead days each year. In addition to the reduced housing and court administration costs, the disutility borne by detainees in prison would be reduced. By observing payouts from the state for wrongful imprisonment, we associate a dollar cost with time detained in prison: $14,285 per year at the lowest, and $400,000 per year at the highest. The associated reduction in disutility each year for reducing the cost of prison to jail would range from nearly $12 million at the lowest and $335 million at the highest, just for detainees in prison which originated from the Cook County Sheriff’s Office.


2. Literature Review

This paper is at the intersection of the criminology and operations management literatures; see Berger et al. (2005) for an introduction to criminology. The criminology literature on incarceration is vast as the history of incarceration goes as far back as that of human civilization; see for example, Morris and Rothman (1995) for a history of prisons. Elsner (2006) provides an account of the correctional system in the U.S. circa 2005. It also highlights various important challenges it faces. Clear (2009) documents the vicious generational cycle of imprisonment that affects the disadvantaged neighborhoods of large U.S. cities through ethnographic studies. We refer readers to BJS (2021) and Myers and Lough (2014) for further background.

The operations management literature that focuses on criminal justice is thin. Maltz (1994) and Maltz (1996) provide overviews circa 1990; also see Blumstein (2007) for an overview of his and his collaborators’ contributions to this field. Early work in the field attempted to broadly model the criminal justice system, see Blumstein and Larson (1969), Reich (1973), Nagel and Neef (1976), Brantingham (1977), Harris and Moitra (1978), Cassidy (1985). More recently, Dabbaghian et al. (2014) model the criminal justice system of British Columbia at a high-level. Zooming in, some work has been devoted to police staffing, patrolling, and dispatch, see Freeman (1992), Swersey (1994), and Green and Kolesar (2004). Seepma (2020) and Hancock and Raeside (2010) analyze communication processes within the criminal justice space. Combining criminal justice, healthcare, and operations, Ayer et al. (2019) study hepatitis C treatment in U.S. prisons and propose effective policies.

Within the intersection operations and criminal justice, a few papers are concerned with detention, as with our paper. Usta and Wein (2015) is the most relevant. They study the effectiveness of the pretrial release and split sentencing policies by estimating the flows between various segments of the criminal justice system. They then evaluate how these policies would trade off reductions in the jail population with increased recidivism risk for the population. They show that split sentencing is more effective for Los Angeles’ estimated process flow. Their work influenced our counterfactual study in Section 8.3. Master et al. (2018) extends this work, assuming that jails may not exceed their population cap by renting space from neighboring precincts, and characterize approximate performance measures for policies which offer pretrial release and split sentencing to detainees. Finally, Korporaal et al. (2000) analyze prison capacity in the Netherlands.

Mathematics is often used in criminology, and because the field of criminal justice can be so tethered to issues of operations, operations and non-operations problems in the field can be difficult to separate. We list some reviews as well as some individual papers which are focused on criminal justice, are quantitative, and are operations-esque for the interested reader. Avi-Itzhak and Shinnar (1973) reviews quantitative models in crime control circa 1970. More recently, Weisburd (2017) reviews quantitative
methods in criminology. Pratt (2014) collects several papers which exemplify the contribution quantitative methods can have on criminal justice. Risk assessment is common throughout the criminal justice space, and has become more quantitative over time; see Yang et al. (2010) for a review of nine risk assessment tools. Wang and Wein (2018) and Wang et al. (2020) study and propose policies to reduce the backlog of untested sexual assault kits in the USA. Wang et al. (2017) and Wang et al. (2018) analyze ballistic imaging systems, and propose policies which pair firearms and cartridge cases from crime scenes and test fires more efficiently.

Methodologically, our model of detainee costs resembles those seen in the structural estimation literature. The seminal papers Rust (1987) and Berry et al. (1995) are among the first in this area, also see Nevo (2000). In particular, the market share constraints in our model are analogous to those of Berry et al. (1995) and Nevo (2000). More recently, structural estimation has been used for a wide range of applications in operations management. Olivares et al. (2008) study the structural estimation of a newsvendor model and apply it to operating room scheduling, also see Musalem et al. (2010) for structural estimation of stock-outs. Similarly, Akşin et al. (2013), Akşin et al. (2017) and Ata et al. (2017) study structural estimation of the delay sensitivity of call center customers and surrounding theoretical questions. Li et al. (2014) study the behavior of customers in the air-travel industry, making use of a structural estimation model to impute the fraction of strategic customers in the population. Moon et al. (2018) empirically study markdown pricing using structural estimation; also see Bimpikis et al. (2020). Bray et al. (2019) explores consequences of the bullwhip effect using structural estimation. Buchholz (2018) and Ata et al. (2019) use structural estimation to study the behavior of taxi drivers in New York City using ride data. Dong et al. (2020) study mobile money markets. Shen et al. (2020) studies a healthcare application. The authors use a structural model to demonstrate differences in emergency departments’ admission behavior during peak periods, and suggest policies to alleviate the inefficiencies caused by this behavior. Also in the healthcare domain, Agarwal et al. (2021) and Ata et al. (2020) use structural estimation to study the deceased-donor kidney allocation system in the U.S. We refer the reader to Musalem et al. (2017) for a recent, more detailed review of this stream of literature.

Finally, our structural model relies on estimating delaying detainees’ case length distributions from a set of positive and unlabeled data. We refer to Bekker and Davis (2020) for a comprehensive review on this subject.

3. The Criminal Justice System Through an Operations Management Lens

In this section, we provide an operations-focused summary of how detainees move through the (often complex) criminal justice system. Following the convention of the Bureau of Justice Statistics (BJS) (BJS 2021), a detainee’s case can be thought of in three parts: prosecution and pretrial services,
adjudication, and sentencing, which roughly translate to the beginning, middle, and end of their case, see Figure 2. We refer to “pretrial” as the entire duration before sentencing, and “post-sentencing” as everything afterward. We focus on the processes and outcomes which are most common and are relevant to the analysis in this paper. For more detailed descriptions, we refer readers to (BJS 2021) and (Myers and Lough 2014). We use the terms “person,” “defendant,” and “detainee” to refer to the accused individual as appropriate during their case.

<table>
<thead>
<tr>
<th>Prosecution &amp; Pretrial Services</th>
<th>Adjudication</th>
<th>Sentencing</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Arrest</td>
<td>1. Arraignment</td>
<td>Guilty</td>
</tr>
<tr>
<td>2. Charges levied</td>
<td>2. Recurring court visits</td>
<td>Not guilty</td>
</tr>
<tr>
<td>4. Pretrial detention determined</td>
<td></td>
<td>Jail</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Probation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Supervision</td>
</tr>
</tbody>
</table>

Figure 2  A Three Step Process Through the Criminal Justice System.

**Prosecution and Pretrial Services.** A person’s case typically begins after an arrest or grand-jury indictment. Within a few days, the courts move through pretrial administrative procedures which allow the case to proceed. First, the prosecutor files charges against the defendant, enumerating the laws they are accused of breaking. The defendant is assigned a defense attorney, i.e. public defender, if needed. Then, the charges are reviewed in a preliminary hearing to ensure that there is probable cause for the case to continue—otherwise charges are dropped or dismissed. During this time, “pretrial services” collect relevant data about the defendant, such as their criminal history, residence, and drug use.

If the case continues, the defendant is quickly brought to bond court. This will determine the defendant’s pretrial detention status. They can either be released, detained on Electronic Monitoring (EM), or detained in jail. The bond court judge evaluates the defendant and their case on two metrics: their likelihood to return for trial and their likelihood of being a danger to the community. The judge then assigns a bond, which stipulates the defendant’s conditions for pretrial release, if any. These conditions are typically monetary, but can incorporate special qualifications such as EM, home visits from police, or surrendering of passports.

The most common bonds are monetary bail bonds. The three primary types are I, D, and cash. Each lists a dollar amount, such as $50,000-D, which indicates the penalty for not appearing for court.
The three differ by what fraction of the listed amount the detainee must post (pay) up front for release. I-bonds (individual recognizance bonds) require no up front payment. D-bonds (deposit bonds) require 10% up front. Cash bonds require 100%. If the defendant is present for court, any up front payments are returned, although court fees are sometimes taken from the posted bond. If they cannot pay the required amount for a D or cash bond, defendants are detained in jail pretrial.

As mentioned above, another condition which can be imposed on detainees is EM. On EM, defendants may return home pretrial but are monitored by a GPS device. Depending on the circumstances of the case, defendants may be allowed to move between approved areas, such as home and work. Leaving the approved areas or removing the GPS device violates their bond conditions and can lead to more severe charges.

The judge may also decide to detain the defendant until their case is complete. This is referred to as “no bail.” In this case, there are no conditions the defendant can meet to be released pretrial.2

**Adjudication.** Adjudication is the portion of the case devoted to determining the guilt or innocence of the detainee. It takes place after the bond hearing, and begins with an arraignment hearing. It ends when the detainee receives a verdict of guilty or not guilty. This is generally the longest part of the case (see Section 4 for more detailed information about case lengths).

The defendant initially pleads guilty or not guilty to their alleged charges during the arraignment hearing. A plea of not guilty is most common during arraignment. However, defendants frequently switch their plea to guilty when accepting plea bargains later in their case.3

After the arraignment hearing, defendants visit court multiple times before their case ends. These visits span a wide range of purposes, such as administrative motions in the case, discovery of evidence, coordination of witnesses, and communication between attorneys. The defendant’s case persists during this time because of “continuances”—motions by the attorneys that table the case to a future date to ensure it is properly adjudicated. The prosecution and judge are limited in this capacity because defendants have a right to a speedy trial, see Appendix B. Thus, most continuances come from the defense. The recurring court visits that arise due to these continuances are typically spaced 3-5 weeks apart. It is not uncommon for cases to extend longer than a year during this time.

Adjudication ends when the defendant is found guilty or not guilty. Defendants are guaranteed the right to a trial by jury. They may also forgo the jury and instead opt for a bench trial, where the judge serves the jury’s role. However, the vast majority (over 95%) of cases conclude because of a

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2 In accordance with the severity of this bond, when no bail is set, the judge reads a script which outlines the test that they use to determine that no bail is appropriate. It reads: “The proof is evident and the presumption great that the defendant is guilty of the alleged crimes. It is clear that the defendant represents a clear and present danger to the community, and there are no conditions which can reasonably ensure the defendant’s return.”

3 At any stage, a guilty plea must be evaluated by the judge to ensure the defendant was not coerced and understands the implications of the plea. If accepted, the judge may then determine the defendant’s sentence.
plea bargain. In these cases, the defendant admits guilt for a set of charges in exchange for a known sentence negotiated with the prosecution. If the defendant is found not guilty, no sentence is imposed. If they are found guilty, the judge hands down a sentence during their sentencing hearing.

**Sentencing.** The judge administers a sentence for any detainee found guilty. They are composed of two parts: a location and a duration. Prison is the most common location, followed by jail. Jail sentences are typically reserved for misdemeanors or short felony sentences. In both cases, any time the detainee spent incarcerated in jail or on EM pretrial counts toward their sentence duration. These sentences are also subject to sentence credit, which allows detainees to serve as little as half of their sentence duration if found guilty of low-level crimes, see Appendix A for further details.

Supervision and probation are less severe sentences. They do not require detention post-sentencing, but still restrict detainees following a guilty verdict. Supervision typically stipulates that the detainee not reoffend during a set period. If successful, their charges are often eligible for removal from their criminal record. Probation is more severe. In addition to not reoffending, detainees are typically required to meet with a probation officer and pass regular drug tests. Charges which result in probation are usually not eligible for removal from the detainee’s criminal record.

### 4. Data

Our dataset primarily consists of data retrieved from the Cook County Office Offender Management System (CCOMS) via the Cook County Sheriff’s Office (CCSO). We also make use of data from the Illinois Department of Corrections (IDOC), the state’s prison system. We use five data files which collectively provide the data fields listed in Table 1. Each contributes the following information:

- The beds file lists the detainees’ pretrial housing location.
- The bonds file lists the detainees’ bond type and amount.
- The courts file lists the detainees’ court dates.
- The IDOC file has data about people detained in prison, which we use to determine sentence durations for detainees sentenced to prison.
- The main CCOMS file provides all remaining data fields in Table 1.

In sum, these data represent a clear picture of the detainees’ detention from arrest through sentencing. We focus attention on detainees booked in 2015 and 2016 and who remained in the CCSO’s custody either on EM or in jail. They correspond to 98,882 rows in our dataset, each row representing one detainee’s booking.

We describe each data field below. Finally, we conclude this section with a brief summary of how our data is cleaned and which portion of the dataset is used for analysis in Sections 5 and 6.
<table>
<thead>
<tr>
<th>Detainee</th>
<th>Housing</th>
<th>Case</th>
<th>Sentencing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inmate ID</td>
<td>Booking ID</td>
<td>Docket number</td>
<td>Sentence location</td>
</tr>
<tr>
<td>Criminal history</td>
<td>Booking date</td>
<td>Crime class</td>
<td>Sentence duration</td>
</tr>
<tr>
<td>Prison history</td>
<td>Pretrial housing location</td>
<td>Case length</td>
<td>Turnaround status</td>
</tr>
<tr>
<td></td>
<td>Security classification</td>
<td>Court dates</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Bond type</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Bond amount</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 1  Data Fields.

4.1. Detainee Information

**Inmate ID.** Each detainee is assigned a unique identifier which does not change between cases or bookings.

**Criminal History.** We score defendants’ criminal history with a metric that approximates the United States Sentencing Commission’s (USSC) criminal history metric (USSC 2019). Our metric is approximate because we only have access to criminal data from Illinois, while the USSC Criminal History metric incorporates national data.

In our metric, each detainee is given a criminal history score. They are assigned 3 points for each prior prison sentence, 2 points for each prior jail sentence, and 1 point for each prior probation or supervision sentence. We bucket these criminal history scores into four descriptive bins: “None”, “Low”, “Medium”, and “High”, each accounting for about 25% of the data.

**Prison History.** This data field indicates if the detainee has been sentenced to an Illinois prison in the past.

4.2. Housing Information

**Booking ID.** The CCSO assigns detainees a unique booking ID distinguishing each time they are booked in jail or on EM.

**Booking Date.** This is the date the detainee is placed under the responsibility of the CCSO for each booking. We use this date as the beginning of both the detainee’s case and detention.

**Pretrial Housing Location.** There are two pretrial housing locations under the CCSO’s purview: EM and jail. In our data, 13.8% of detainees are on EM pre-trial and 86.1% are in jail pre-trial.

**Security Classification.** The CCSO classifies each detainee as either minimum, medium, or maximum security while under their purview.

**Bond Type.** As mentioned in Section 3, detainees are assigned a bond during their bond hearing, which outlines conditions they must meet for release from jail. The relative frequency of bond types is given in Table 2.

**Bond Amount.** As mentioned in Section 3, I, D, and cash bonds are associated with dollar amounts. Figure 3 displays histograms of these amounts for the bonds in our dataset. Recall that for these bonds,
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<table>
<thead>
<tr>
<th>Bond Type</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>D Bond</td>
<td>70.3%</td>
</tr>
<tr>
<td>No Bond</td>
<td>18.2%</td>
</tr>
<tr>
<td>I Bond</td>
<td>5.8%</td>
</tr>
<tr>
<td>I Bond with EM</td>
<td>3.7%</td>
</tr>
<tr>
<td>D Bond with EM</td>
<td>1.0%</td>
</tr>
<tr>
<td>Cash Bond</td>
<td>0.9%</td>
</tr>
</tbody>
</table>

Table 2  **Bond Types.** Bond types listed in decreasing order of frequency for detainees housed in jail. “I Bond with EM” and “Deposit Bond with EM” indicate that the detainee will be released onto EM if bond is posted.

detainees must pay 0%, 10%, and 100% for release, respectively, but are responsible for the full amount if they violate their bond by not arriving for court or re-offending during release. Histograms of bond amounts are given in Figure 3. Note that the masses near zero are not exactly zero—bonds are often listed for values less than $1,000.

![Histograms](image)

**(a) Bond Amounts Less Than $500,000**

![Histograms](image)

**(b) Bond Amounts Less Than $100,000**

*Figure 3  Histograms of Bond Amounts by Bond Type. (3a) displays histograms of bond amounts less than $500,000 in the dataset. (3b) displays histograms of bond amounts less than $100,000 for easier readability of smaller bond amounts. Both are grouped by I, D, and Cash Bonds. I and D bonds include those with EM conditions. In all cases, these amounts are as listed on the bond; bond type determines the amount a detainee would need to play for release.*
4.3. Case Information

**Docket Number.** The docket number is a unique ID number assigned by the courts for each case.

**Crime Class.** At the outset of a case, the prosecution levies charges which enumerate the laws the defendant is accused of breaking. Charges are bucketed into different “crime classes,” which represent the severity of the crime. This class incorporates a combination of the alleged illegal act(s), details about the case, and the defendant’s criminal history. During sentencing, crime class often determines the minimum and maximum sentence the judge can assign. There are nine primary crime classes in Illinois: six for felonies (M, X, 1, 2, 3, and 4) and three for misdemeanors (A, B, and C) (Divito 2001). Table 3 lists each with their frequency in the data and example charges. In the data, 12% of charges fall into other miscellaneous categories, such as petty crimes.

<table>
<thead>
<tr>
<th>Class</th>
<th>Frequency</th>
<th>Classification</th>
<th>Example Charge</th>
<th>Sentence Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>M</td>
<td>0.6%</td>
<td>Felony</td>
<td>First-degree murder</td>
<td>20-60 Years</td>
</tr>
<tr>
<td>X</td>
<td>0.6%</td>
<td>Felony</td>
<td>Aggravated criminal sexual assault</td>
<td>6-30 Years</td>
</tr>
<tr>
<td>1</td>
<td>5.5%</td>
<td>Felony</td>
<td>Second-degree murder, residential burglary</td>
<td>4-15 Years</td>
</tr>
<tr>
<td>2</td>
<td>8.0%</td>
<td>Felony</td>
<td>Kidnapping, arson</td>
<td>3-7 Years</td>
</tr>
<tr>
<td>3</td>
<td>7.7%</td>
<td>Felony</td>
<td>Perjury</td>
<td>2-5 Years</td>
</tr>
<tr>
<td>4</td>
<td>25.4%</td>
<td>Felony</td>
<td>Stalking</td>
<td>1-3 Years</td>
</tr>
<tr>
<td>A</td>
<td>30.1%</td>
<td>Misdemeanor</td>
<td>Criminal trespass</td>
<td>&lt;1 Year</td>
</tr>
<tr>
<td>B</td>
<td>2.5%</td>
<td>Misdemeanor</td>
<td>Aggravated speeding</td>
<td>&lt;.5 Years</td>
</tr>
<tr>
<td>C</td>
<td>1.6%</td>
<td>Misdemeanor</td>
<td>Disorderly conduct</td>
<td>&lt;30 Days</td>
</tr>
</tbody>
</table>

**Table 3  Crime Classes in Illinois.** Crime classes in Illinois in descending order of severity. Example charges are listed for each crime class. Sentence duration is given as a range of the typical minimum and maximum possible sentence for that crime class (Divito 2001).

**Case Length.** A detainee’s case length represents their time between booking (at the outset of their case) and release from pretrial detention (at their time of disposition and sentencing, if applicable). Figure 4a displays a histogram of all case lengths within the dataset. Figures 4b and 4c display case length grouped by pretrial housing location. Cases in which detainees are on EM tend to be longer, and also have a characteristically different shape.

Notice the “spike” in frequency of cases that ended at half a year for detainees on EM. These correspond to one of the most common prison sentences: half a year. This spiking behavior is most stark on EM, but can also be seen for detainees in jail convicted of class 4 felonies and sentenced to prison. We highlight some of these spikes in Figure 5.

Detainees with different sentence locations, crime classes, and housing locations have characteristically different case length distributions. More severe crime classes tend to have longer cases. Prison sentences are associated with the longest cases. Cases where detainees are housed in jail tend to end earlier than
Figure 4  **Histograms of Case Lengths.** Histograms are grouped in the following manner: on the left (in red) (4a) displays a histogram of all detainees in the data. The two histograms on the right (in black) partition the data into detainees in jail (4b) and detainees on EM (4c). Bins for these histograms are one week wide. Case lengths are truncated at two years for readability.

Figure 5  **Case Lengths of Detainees Sentenced to Prison by Crime Class and Pretrial Housing Location.** Histograms are grouped by crime class (decreasing in severity from left to right, focusing on classes 1, 2, 3, 4, and A) and pretrial housing location (in jail on top in red, on em on bottom in black). We’ve added orange ovals to highlight prominent spikes at common sentence durations for prison. Case lengths are truncated at 2 for readability.

cases where detainees are housed on EM. Also, detainees on EM have larger probability masses for case lengths near common sentence locations.

**Court Dates.** The dataset lists each detainee’s court dates. From these, we compute the number of court visits each detainee had, and the court visits’ interarrival times. We also use consecutive court visits at the end of a case to impute which detainees went to trial and which detainees accepted plea bargains.
Number of Court Visits. Defendants in the dataset visit the courts 4.9 times on average per case. As the severity of the crime increases, so do the average number of court visits. Table 4 shows descriptive statistics regarding the number of court visits for each crime class.

<table>
<thead>
<tr>
<th>Class</th>
<th>Mean</th>
<th>Median</th>
<th>Std. Dev.</th>
</tr>
</thead>
<tbody>
<tr>
<td>M</td>
<td>25.6</td>
<td>7</td>
<td>13.3</td>
</tr>
<tr>
<td>X</td>
<td>11.4</td>
<td>19</td>
<td>26.5</td>
</tr>
<tr>
<td>1</td>
<td>8.6</td>
<td>5</td>
<td>10.1</td>
</tr>
<tr>
<td>2</td>
<td>8.5</td>
<td>5</td>
<td>11.2</td>
</tr>
<tr>
<td>3</td>
<td>6.8</td>
<td>4</td>
<td>7.7</td>
</tr>
<tr>
<td>4</td>
<td>4.1</td>
<td>2</td>
<td>5.0</td>
</tr>
<tr>
<td>A</td>
<td>2.2</td>
<td>1</td>
<td>4.1</td>
</tr>
<tr>
<td>B</td>
<td>1.8</td>
<td>1</td>
<td>2.9</td>
</tr>
<tr>
<td>C</td>
<td>1.6</td>
<td>1</td>
<td>2.0</td>
</tr>
</tbody>
</table>

Table 4  Descriptive Statistics of Court Visits by Crime Class.

Court Visit Interarrival Times. The interarrival times of detainee’s court visits are typically an integer multiple of a week. We plot histograms of the interarrival times of detainees’ first five court visits in Figure 6.

Figure 6  Interarrival Times of Court Visits. Histograms truncated at 7 weeks for readability.

Plea Bargains. The majority of cases end in plea bargains, otherwise, they end in a trial. We do not observe this data directly, but can impute it from the detainees’ court visits. Trials are often multi-day events, followed by a not guilty verdict or a sentencing hearing. We detect trials by looking at the interarrival times of the final court visits for detainees found guilty. We say that two or more court visits on consecutive weekdays within a detainees’ final three court visits indicates a trial. Otherwise, we say the detainee plead guilty. 4% of cases in the data is detected to have gone to trial using this method, which is similar to reported statistics by the State’s Attorney Office (Foxx 2018).
4.4. Sentencing Information

**Sentence Location.** Sentence location refers to the location the detainees must spend the remainder of their sentence durations following the conclusion of their cases. Table 5 displays the frequency of different sentence locations by crime class in our dataset. More severe crime classes are associated with more restrictive sentence locations.

<table>
<thead>
<tr>
<th>Class</th>
<th>Charge Dropped or Finding of Not Guilty</th>
<th>Jail</th>
<th>Prison</th>
<th>Probation</th>
<th>Supervision</th>
</tr>
</thead>
<tbody>
<tr>
<td>All</td>
<td>29%</td>
<td>17%</td>
<td>29%</td>
<td>18%</td>
<td>4%</td>
</tr>
<tr>
<td>M</td>
<td>25%</td>
<td>3%</td>
<td>67%</td>
<td>4%</td>
<td>0%</td>
</tr>
<tr>
<td>X</td>
<td>15%</td>
<td>2%</td>
<td>67%</td>
<td>17%</td>
<td>0%</td>
</tr>
<tr>
<td>1</td>
<td>13%</td>
<td>5%</td>
<td>54%</td>
<td>27%</td>
<td>1%</td>
</tr>
<tr>
<td>2</td>
<td>11%</td>
<td>6%</td>
<td>53%</td>
<td>29%</td>
<td>1%</td>
</tr>
<tr>
<td>3</td>
<td>17%</td>
<td>8%</td>
<td>46%</td>
<td>27%</td>
<td>2%</td>
</tr>
<tr>
<td>4</td>
<td>36%</td>
<td>8%</td>
<td>31%</td>
<td>23%</td>
<td>2%</td>
</tr>
<tr>
<td>A</td>
<td>39%</td>
<td>34%</td>
<td>7%</td>
<td>9%</td>
<td>11%</td>
</tr>
<tr>
<td>B</td>
<td>44%</td>
<td>36%</td>
<td>2%</td>
<td>4%</td>
<td>14%</td>
</tr>
<tr>
<td>C</td>
<td>52%</td>
<td>30%</td>
<td>4%</td>
<td>4%</td>
<td>10%</td>
</tr>
</tbody>
</table>

Table 5  **Sentence Locations by Crime Class.** Percentages are based on crime class, i.e. rows sum to one.

**Sentence Duration.** Sentence duration is the amount of time the detainee is incarcerated as a result of a guilty sentence. As mentioned above, time incarcerated in jail or on EM counts toward sentence duration. Additionally, sentences to jail and prison are subject to sentence credit—various programs which reduce the portion of the sentence that the defendant must serve. The most significant is statutory sentence credit, which allows detainees to serve a fraction of their sentence duration, see Appendix A for further details. We present sentences net of their sentence credits—that is, the time the detainee would actually serve.

Histograms of jail and prison sentence durations for the most common classes (1, 2, 3, 4, and A) are given in Figure 7. Prison sentence durations are longer and have large probability masses on the year, half-year, and quarter-year marks. Jail sentence durations are shorter, but can take on many different values. We do not make use of sentence durations for probation and supervision in our analysis. A sentence location of “Charge Dropped or Finding of Not Guilty” indicates that the detainee has no sentence duration, i.e. they will no longer be detained.

**Turnaround Status.** A detainee is a “turnaround” if they are sentenced to prison and their sentence duration (including credit time) is less than their case length. That is, if they spent more time incarcerated pretrial than they were required to spend incarcerated due to their sentence.

In summary, our dataset provides information about detainees’ cases from booking through sentencing. We focus attention on detainees booked in 2015 and 2016 and who remained under the CCSO’s purview either on EM or in jail. This allows us to follow them through the completion of their detention in jail.
Our classification and estimation procedures in Sections 5, 6, and 7 focus on intentional delay behavior and the relative perceived cost of EM, jail, and prison. To estimate these relative costs, we concentrate on detainees who plead guilty, were detained in jail or on EM, whose case lengths were greater than 60 days, and were sentenced to prison. We use turnarounds as signals for delaying behavior for developing a classifier in Section 5. We also restrict our focus to detainees whose primary charges are classes 1, 2, 3, 4, and A; removing classes X and M because they are too severe and classes B and C because they rarely result in pretrial detention. Finally, we remove detainees whose sentence was greater than 4 years pre-sentence credit because of the implied severity of the crime. In combination, these restrictions allow us to focus on detainees who potentially delayed.

Our counterfactual analysis in Section 8 focuses on detainees who entered CCSO custody during 2015-2016 and uses the whole dataset corresponding to those years to calculate the jail population. If delaying behavior is analyzed, as done in counterfactuals 1, 3, and 4, we simulate delaying behavior for the subset of detainees for whom we have the case length distributions and perceived housing costs. Namely, detainees who are housed in jail or on EM, were sentenced to jail or prison, whose crime classes are 1, 2, 3, 4, or A, whose sentence was less than 4 years pre-sentence credit, and whose case length was greater than 60 days. The rest of the detainees either remain in the CCSO’s custody for a short duration if at all, e.g., crime classes B, C, or their charges are too severe, e.g., crime classes X, M, and hence the nature and the evolution of their cases is very different. The latter group of detainees constitute a negligible portion of the jail population.
5. Case Length Distributions

In our model, each detainee decides to either intentionally delay or not. Our analysis of intentional delay behavior requires an understanding of detainees’ case length distributions when they intentionally delay (D) or not (N). In this section, we describe how we use the SAR-EM method to estimate those distributions.

The intentional delaying behavior is unobserved in the data. Instead, we receive a signal, $\tau$, which partially labels the delaying detainees. That is, if the detainee delayed, $y = 1$, then there is a chance they are labeled as such: $\tau = 1$. But the remainder of the delaying detainees and all of the non-delaying detainees are unlabeled, $\tau = 0$. In other words, if a detainee is labeled, i.e. $\tau = 1$, then he delayed intentionally, i.e. $y = 1$. This exemplifies a Positive and Unlabeled (PU) dataset.

Recall that some detainees’ case lengths may exceed their sentence duration, who are referred to as turnarounds. We adopt turnaround status as a signal of intentionally delaying within our dataset. That is, if the detainee is a turnaround, $\tau = 1$.

We calculate an expected probability of intentionally delaying for each detainee, $\hat{y}$, using an Expectation Maximization algorithm developed by Bekker and Davis (2020) called SAR-EM. As a preliminary to describing the algorithm, we first review the underlying probabilistic primitives. We consider our data described by a tuple $(x, y, \tau)$ whose distribution is governed by $Pr(x, y, \tau) = Pr(x) Pr(y|x) Pr(\tau|x, y)$.

Our implementation of the SAR-EM algorithm uses two machine learning models: the expected classification model $f(x|\theta)$ and the propensity score model $e(x|\phi)$. The expected classification model is used to approximate $Pr(y|x)$. The propensity score model is used to approximate $Pr(\tau|x, y)$. Both models $f$ and $e$ are selected from a list of classification models. They are parameterized by vectors $\theta$ and $\phi$, respectively. Given the models $f$, $e$, the SAR-EM procedure starts with initial values for these parameters and updates them iteratively through the expectation and maximization steps. Each iteration starts with the current parameters, denoted by $\theta^{old}$ and $\phi^{old}$. Then the expectation step calculates $\hat{y}$ for each detainee, i.e. their expected probability of intentionally delaying, using $\theta^{old}$, $\phi^{old}$. Next, given $\hat{y}$ for each detainee, the maximization step reoptimizes the parameters yielding $\theta^{new}$ and $\phi^{new}$, which replace $\theta^{old}$ and $\phi^{old}$ as the current parameters. These two steps are performed iteratively until the algorithm converges.\textsuperscript{4}

Next, we describe the expectation and maximization steps formally.

**Expectation Step.** In this step, we find $\hat{y}$ for each detainee given our current models $f$ and $e$. These models are fit with the current parameters $\theta^{old}$ and $\phi^{old}$. For a detainee $i$, we set

$$\hat{y}_i^{new} = Pr(y_i = 1|\tau_i, x_i, \theta^{old}, \phi^{old}) = \tau_i + (1 - \tau_i) \frac{f(x_i|\theta^{old})(1 - e(x_i|\phi^{old}))}{1 - f(x_i|\theta^{old})e(x_i|\phi^{old})}.$$ \textsuperscript{4} At the outset of the algorithm, $f$ and $e$ are initialized with a short procedure training them directly on the labels $\tau$. 

In practice, the propensity score \( e \) is “decayed” by a parameter \( d \in [0, 1] \) to avoid local maxima where \( f \) returns 1 for any input. So, \( \hat{y} \) is given by:

\[
\hat{y}_i^{\text{new}} = \Pr(y_i = 1 | \tau_i, x_i, \theta^{\text{old}}, \phi^{\text{old}}, d) = \tau_i + (1 - \tau_i) \frac{f(x_i | \theta^{\text{old}})(1 - d e(x_i | \phi^{\text{old}}))}{1 - f(x_i | \theta^{\text{old}}) d e(x_i | \phi^{\text{old}})}.
\]

**Maximization Step.** Given the updated \( \hat{y}^{\text{new}} \), we find the model parameters which maximize the log-likelihood of observing \( x \) and \( \tau \). Bekker and Davis (2018) show that the models \( f \) and \( e \) which achieve this maximum satisfy the following two equations:

\[
\theta^{\text{new}} = \arg \max_\theta \sum_{i=1}^I [\hat{y}_i^{\text{new}} \ln f(x_i | \theta) + (1 - \hat{y}_i^{\text{new}}) \ln (1 - f(x_i | \theta))]
\]

\[
\phi^{\text{new}} = \arg \max_\phi \sum_{i=1}^I \hat{y}_i^{\text{new}} [\tau_i \ln e(x_i | \phi) + (1 - \tau_i) \ln (1 - e(x_i | \phi))]
\]

Then we update the parameters: \((\theta^{\text{old}}, \phi^{\text{old}}) \leftarrow (\theta^{\text{new}}, \phi^{\text{new}})\), and iterate until convergence. Convergence occurs when the change of outputs between iterations of \( e \) is smaller than some \( \epsilon \). Once the algorithm converges, letting \( \theta^*, \phi^* \) denote the final parameter values, we set the probability of delaying for detainee \( i \) as \( \hat{y}_i = f(x_i | \theta^*) \). After doing this for all detainees, we use those probabilities to create binary predictions of delaying behavior by comparing them with a threshold \( \alpha \). Predicted probabilities greater than or equal to \( \alpha \) are said to be delaying, \( \tilde{y} = 1 \), otherwise they are not, \( \tilde{y} = 0 \). Formally, we have

\[
\tilde{y} = \begin{cases} 
0 & \text{if } \hat{y} < \alpha, \\
1 & \text{if } \hat{y} \geq \alpha.
\end{cases}
\]

For further details of the implementation, see Bekker and Davis (2020).

In order to choose the threshold \( \alpha \), we follow Lee and Liu (2003), who developed a metric for our setting (positive and unlabeled data) that approximates the traditional \( F_1 \) metric\(^5\) and is often used in the literature. It relies on a modified recall \( \hat{r} = \Pr(\tilde{y} = 1 | \tau = 1) \), and is given by:

\[
F_1 = \frac{\hat{r}^2}{\Pr(\tilde{y} = 1)}
\]

The term \( \hat{r} \) is the fraction of detainees labeled as intentionally delaying by the SAR-EM algorithm among those who were positively labeled in the data, i.e. \( \tau = 1 \). The denominator represents the fraction of detainees which SAR-EM labels positively. This metric has qualitative features that are similar to the traditional \( F_1 \) metric—for it to be high, precision and recall must be high. The higher this metric the better the classifier performs.

\(^5\) The traditional \( F_1 \) metric, \( F_1 = 2pr / (p + r) \), is the harmonic mean of precision \( (p = \Pr(y = 1 | \tilde{y} = 1)) \) and recall \( (r = \Pr(\tilde{y} = 1 | y = 1)) \). Where \( \tilde{y} \) are the binary predicted classifications from \( f \). Notice that for a high \( F_1 \) score, precision and recall must be high. However, in the PU setting that information on \( y \) is obscured, so this metric cannot be used. Thus a similar metric is necessary for PU settings.
This modified $F_1$ score is a function of binary predictions, $\tilde{y}$, thus it is dependent on the threshold used to determine classification, $\alpha$. The $\alpha^*$ which maximizes this metric is used to classify detainees for our estimation procedure.

**Implementation and Resulting Case Length Distributions.** We implemented the SAR-EM algorithm using Python, building on the code developed by Bekker and Davis (2020). The data used is briefly summarized in Table 6 and is discussed in detail in Section 4. In particular, we restrict our attention to detainees with prison sentences, as turnarounds are used as a signal for classification purposes.

<table>
<thead>
<tr>
<th>Features</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phase 1 Housing Location</td>
</tr>
<tr>
<td>Crime Class</td>
</tr>
<tr>
<td>Case Length</td>
</tr>
<tr>
<td>Sentence Duration</td>
</tr>
<tr>
<td>The Ratio of Case Length and Sentence Duration</td>
</tr>
<tr>
<td>The Average of the First Five Court Visit Interarrival Times</td>
</tr>
<tr>
<td>Number of Court Visits</td>
</tr>
<tr>
<td>Security Classification</td>
</tr>
<tr>
<td>Z-score of Case Length Grouped by Crime Class</td>
</tr>
</tbody>
</table>

Table 6 **Features Used in SAR-EM Classification.** The listed features are used as data in SAR-EM. We also include polynomial transformations of all features up to quadratic terms. That is, linear terms for each, interaction terms between each, and quadratic terms for each. The resulting dataset has 8,346 rows and 209 features.

We discuss the selection of models and hyperparameters in Appendix C. Logistic regression performed best for both models. The threshold $\alpha^* = 0.556$ achieves the maximum modified $F_1$ score with these parameters. The fraction of detainees labeled delaying and the performance of the classification, both over $\alpha$ are given in Figures 8a and 8b.

We classify each detainee in the dataset using our threshold $\alpha^*$. After classification, 43.4\% of detainees are predicted to have delayed. We group their case length distributions by both crime class and pre-trial housing location so they depend on detainee characteristics. Histograms of the resulting 20 case length distributions for delaying and non-delaying detainees are given in Figure 9. These are used as $F_D$ and $F_N$ in our estimation described in Section 6. Notice that non-delaying distributions are smaller than

---

6 For $f$, the classification model, the regularization parameter is 2.15. For $e$, the propensity score model, the regularization parameter is 100. The propensity decay score is 0.8.

7 These two covariates provide the most information about detainees’ case length distributions while keeping the sample size of each group large enough for the empirical distribution to be reliable. We discuss their effects on the case length distributions in Section 4. To adapt the empirical distributions into $F_D$ and $F_N$, we bucket case lengths into month-wide bins. This mimics the accuracy of detainees’ ability to control their case lengths—average interarrival times of court dates are nearly a month—and helps ensure that the cdf of the distribution has robust support along its domain.
(a) Fraction Delaying over $\alpha$.  

(b) Modified $F_1$ Score Over $\alpha$.

**Figure 8** Results of SAR-EM Classification. SAR-EM produces a predicted probability of delaying for each detainee. As $\alpha$ changes, so does the performance of the classification and fraction of detainees labeled positively. The maximal modified $F_1$ score of 2.267 is achieved at $\alpha^* = 0.556$.

delaying distributions, and tend to decrease monotonically as case length increases. Case lengths for delaying detainees tend to be longer and have increased probability densities near common sentence durations.

### 6. Structural Estimation of Detainees’ Location Costs

In this section, we develop a structural estimation model to estimate detainees’ relative perceived costs of being detained in EM, jail, and prison. We assume a detainee’s cost is linear in their length of stay, but his cost rate can differ across different locations. Because pre-trial detention time counts against sentence duration, detainees can loosely balance the amount of time they spend at different housing locations by either intentionally delaying their case or letting it follow its natural course. This choice results in different case length distributions for each detainee. Such variation in the data allows us to identify the cost parameters. In doing so, we allow (unobserved) heterogeneity among detainees’ cost rates and estimate the distribution of the cost rate per time unit for each location. To be more specific, we seek the cost parameters that maximize the likelihood of detainees’ case lengths observed in the data. In doing so, we restrict attention to detainees who are sentenced to prison and were either on EM or held in jail pretrial. The results of this Maximum Likelihood Estimation are presented in Section 7 and are used in our counterfactual analysis in Section 8.

Detainees have two phases in which they can be incarcerated and thus accrue housing costs: pre-sentencing (or phase 1) and post-sentencing (or phase 2). During phase 1, detainees can be held in jail ($J$) or electronic monitoring ($EM$). During phase 2, detainees are incarcerated in prison ($P$).
(a) Delaying Case Lengths: $F_D$  
(b) Non-Delaying Case Lengths: $F_N$

Figure 9  Histograms of Estimated Case Lengths. Histograms of $F_D$ and $F_N$ following the SAR-EM classification. In this classification procedure, we restrict our attention to detainees with prison sentences.
Let \( l_i \in \{EM, J\} \) denote detainee \( i \)'s phase 1 location and \( P \) denote his phase 2 location of prison. He incurs a linear cost of \( c_i(l) \) in location \( l \) per unit of time he is incarcerated there. We denote his case length by \( W_i \) and his sentence duration by \( S_i \). Because the detainees we focus on plea guilty, they know their sentence duration in phase 1. As mentioned earlier, the time detainees spend incarcerated pre-trial counts toward their sentence duration. Thus, detainee \( i \) spends \( w_i \) in location \( l_i \in \{EM, J\} \) and \((s_i - w_i)^+\) in prison. If the detainee’s case length exceeds their sentence, he is immediately released upon sentencing. In particular, he is a turnaround.

Detainee \( i \) chooses an action \( a_i \in \{D, N\} \), representing intentionally delaying or not, respectively. These actions result in different case length distributions, \( W_i \), with cdfs (pdfs) \( F_{a_i}(w_i) (f_{a_i}(w_i)) \) from which each detainee’s case length is drawn.

**Cost Structure and Probability of Delaying.** Let \( C_i(A) \) denote the expected cost of incarceration for detainee \( i \), who chooses action \( a_i = A \), with phase 1 housing location \( l_i \) and sentence duration \( s_i \):

\[
C_i(A) = c_i(l_i)E_A[W_i] + c_i(P)E_A[(s_i - W_i)^+],
\]

where the expectation is taken over \( W_i \) under \( F_A \) for \( A \in \{D, N\} \).

Detainees are heterogeneous in their perceived costs of detention. We assume that each detainee draws his cost parameters from a Gaussian distribution whose mean and standard deviation depend on the detention location. To be specific, we assume that

\[
c_i(l) \sim \mathcal{N}(\mu_l, \sigma_l^2), \quad l \in \{EM, J, P\}.
\]

The following proposition is immediate from Equations (1)-(2).

**Proposition 1.** Detainee \( i \)'s expected cost associated with action \( A \) has a Gaussian distribution with mean \( \bar{\mu}_A(i) \) and variance \( \bar{\sigma}_A^2(i) \) for \( A \in \{D, N\} \), where

\[
\bar{\mu}_A(i) = \mu_l E_A[W_i] + \mu_P E_A[(s_i - W_i)^+],
\]

\[
\bar{\sigma}_A^2(i) = (\sigma_l E_A[W_i])^2 + (\sigma_P E_A[(s_i - W_i)^+])^2,
\]

and \( E_A \) is taken over case length \( W_i \) with respect to the cdf \( F_A \).

Detainees seek to minimize their expected costs by choosing between intentionally delaying their case \( (D) \) or not \( (N) \). We let \( p_i \) denote the probability that detainee \( i \) (with pre-sentencing location \( l_i \) and sentence duration \( s_i \)) choose to intentionally delay his case. We have that

\[
p_i = P(C_i(D) \leq C_i(N)).
\]

The following proposition characterizes \( p_i \).

---

8 We use lower case \( w_i \) and \( s_i \) to denote the realized case length and sentence duration.
Proposition 2. Detainee $i$’s probability of intentionally delaying is given by

$$p_i = \Phi \left( \frac{\bar{\mu}_N(i) - \bar{\mu}_D(i)}{\sqrt{\sigma_N(i)^2 + \sigma_D(i)^2}} \right),$$

or equivalently, in terms of the location cost parameters:

$$p_i = \Phi \left( \frac{\mu_i (E_N[i] - E_D[i]) + \mu_p (E_N[(s_i - W_i)^+] - E_D[(s_i - W_i)^+])]}{\sqrt{\sigma_N(i)^2 + \sigma_D(i)^2} \sigma_p (E_N[(s_i - W_i)^+]^2 + E_D[(s_i - W_i)^+]^2)} \right), \quad \text{(3)}$$

Estimation Formulation. We maximize the likelihood of the observed detainee case lengths given the cost structure outlined above. Detainee $i$’s case length $w_i$ is drawn from cdf $F_D$ if he intentionally delays his case, which occurs with probability $p_i$. Otherwise, $w_i$ is drawn from cdf $F_N$. Letting $L_i(w_i)$ denote the likelihood of detainee $i$’s case length $w_i$, we have that

$$L_i(w_i|\mu EM, \mu J, \mu P, \sigma EM, \sigma J, \sigma P) = p_i f_D(w_i) + (1 - p_i) f_N(w_i), \quad \text{(4)}$$

where $f_D$ and $f_N$ are the pdfs associated with $F_D$ and $F_N$, respectively.

The likelihood of observing case lengths $w_1, \ldots, w_J$, denoted by $L(\mu EM, \mu J, \mu P, \sigma EM, \sigma J, \sigma P)$, is then given by

$$L(\mu EM, \mu J, \mu P, \sigma EM, \sigma J, \sigma P) = \prod_{i=1}^J L_i(w_i|\mu EM, \mu J, \mu P, \sigma EM, \sigma J, \sigma P) \quad \text{(5)}$$

We also require that

$$\frac{1}{|N_l|} \sum_{i \in N_l} \Phi \left( \frac{\bar{\mu}_N(i) - \bar{\mu}_D(i)}{\sqrt{\sigma_N(i)^2 + \sigma_D(i)^2}} \right) = \frac{1}{|N_{EM}|} \sum_{i \in N_{EM}} \hat{y}_i, \quad l \in \{EM, J\} \quad \text{(6)}$$

where the left-hand side is the average probability of intentional delay predicted by our model, whereas the right-hand side is the average predicted probability of delaying derived from the SAR-EM method, see Section 5. We impose this for each pre-trial housing location; $N_l$ denoting the set of detainees housed in those locations pre-trial. Conceptually, this ensures that the proportion of delaying detainees are consistent between our two estimation methods. This constraint can be thought of as similar to the market share constraints in the formulations of Berry et al. (1995) and Nevo (2000).

Moreover, as can be seen from Equation (3), the probability of intentionally delaying is left unchanged if we scale all cost parameters proportionally. Therefore, for identification purposes, we restrict the sum of $\sigma$’s across each location to be one. That is,

$$\sigma EM + \sigma J + \sigma P = 1. \quad \text{(7)}$$

Then the resulting MLE formulation is given as follows:

$$\max_{\mu EM, \mu J, \mu P, \sigma EM, \sigma J, \sigma P} \log \left( L(\mu EM, \mu J, \mu P, \sigma EM, \sigma J, \sigma P) \right) \quad \text{subject to} \quad (6) - (7). \quad \text{(8)}$$
Identification. The structural parameters in our model drive changes in $p_i$, the detainee’s probability of delaying. This, in turn, drives changes in the likelihood function, as long as $f_D \neq f_N$ for most case lengths observed in the data. Simple inspection of the histograms of estimated case lengths in Figure 9 show that this condition holds. Thus, changes in the likelihood function are driven by $p_i$.

\[ E_N[|W_i|] - E_D[|W_i|] \]
\[ E_N[(s_i - W_i)^+] - E_D[(s_i - W_i)^+] \]
\[ E_N[|W_i|^2] + E_D[|W_i|^2] \]
\[ E_N[(s_i - W_i)^+|^2] + E_D[(s_i - W_i)^+|^2] \]

Figure 10  Histograms of Coefficients of $\mu$ and $\sigma$. Figures 10a and 10c plot the coefficients of $\mu_l$ and $\sigma_l$ for jail and EM. Similarly, Figure 10b and Figure 10d plot the coefficients of $\mu_P$ and $\sigma_P$ for prison.

As previously mentioned, $p_i$ remains unchanged if all cost parameters are scaled proportionally. After restricting the sum of $\sigma$’s across location to be one, variation in the coefficients of the cost parameters drives their identification, see Equation (3). Specifically, variation in the expectations in the numerator drive the identification of $\mu$’s, and variation in the expectations in the denominator drive the identification of $\sigma$’s. We plot histograms of the calculated values of the four coefficients in Figure 10. They exhibit significant variation to identify the parameters. The coefficients of the pretrial housing locations have 10 possible realizations based on the five crime classes and two pretrial housing locations used to develop $F_D$ and $F_N$. Recall that the case length distributions depend on both the crime class (1, 2, 3, 4, A) and the housing location (EM or jail). The coefficients of the prison cost
parameters are even more varied, as they incorporate sentencing data in addition to crime class and housing location.

Intuitively, these coefficients represent the difference in time detainees are incarcerated at the three detention locations. For our model to identify detainee costs, there must be significant variation in this time depending on the detainee’s choices. Because our estimated delaying and non-delaying distributions are quite different from each other, and differ between crime classes and pretrial housing locations, our model can identify the parameters of detainees’ location costs.

7. Estimation Results

<table>
<thead>
<tr>
<th>Location</th>
<th>Estimated $\mu$</th>
<th>Estimated $\sigma$</th>
</tr>
</thead>
<tbody>
<tr>
<td>EM</td>
<td>0.370</td>
<td>0.241</td>
</tr>
<tr>
<td>Jail</td>
<td>1.378</td>
<td>0.446</td>
</tr>
<tr>
<td>Prison</td>
<td>1.835</td>
<td>0.313</td>
</tr>
</tbody>
</table>

Table 7 Estimated Location Cost Parameters. Estimates are truncated at three decimal places for readability. Standard errors are listed in parentheses below the estimates.

We maximize the log-likelihood formulation of Equation 8 using the nonlinear optimization solver KNITRO (Byrd et al. 2006) via the AMPLpy interface (Brandão 2021).9 The resulting parameters of the location cost distributions are given in Table 7 and the resulting pdfs are plotted in Figure 11. To compute each parameter’s standard error, we perform the non-parametric bootstrap method (Horowitz 2001). We generate 500 simulated datasets with the same size as our dataset by drawing from ours with replacement. We then estimate parameters of the simulated datasets and compute their standard errors, which are listed in parentheses in Table 7. Appendix D describes a Monte Carlo simulation study to illustrate the identification of our model; we are able to recover the true parameters when using our estimation procedure on simulated data resulting from those parameters.

9To assist in finding a locally feasible point, and to improve the robustness of our results, we consider 40 multistart points.
8. Counterfactual Analysis

This section studies four counterfactuals designed to reduce pretrial detention and save costs. They each address this issue by tackling one of the following: case lengths, bonds, split sentencing, and improving prison conditions. When calculating housing costs for jail, we use $143 per inmate per day in jail (Board of Commissioners of Cook County 2021).

The counterfactual studies in Sections 8.1, 8.3, and 8.4 involve simulating the detainees’ intentional delaying behavior. Whenever this is needed, we simulate their behavior using 50 replications and report the average.

8.1. Straightforward Operational Improvements

Straightforward improvements to the Cook County court system could curtail unnecessary administrative court visits for detainees. Many continuances result from the court’s outdated, non-digital adjudicatory practices. In their review of the Cook County courts’ pre-trial detention, (Staudt 2020) Chicago Appleseed noted:

“In the federal courts, and most other major state court systems, pieces of evidence are exchanged electronically as soon as they are received by the prosecutor. The Cook County Circuit Court continues to adhere to the outdated practice of physically exchanging paper copies of documents and CDs and DVDs of audio and video recordings only in court, not between court dates. As the

Figure 11  Estimated Location Cost pdfs. The plotted densities, from left to right, represent the estimated distribution of location costs for EM, jail, and prison.
amount of digital evidence in cases rapidly increases, this process is even more cumbersome than it was a decade ago.”

In addition to exchanging evidence electronically, automatically delivering common pieces of evidence, such as body camera footage, can speed up discovery by weeks. Centralizing where various types of court visits take place make scheduling more efficient.

In a 2019 audit of the courts, the National Center for State Courts identify the benefits Cook County could reap from these style of improvements (National Center for State Courts 2019). These benefits include the following:

• A reduction in case continuances and postponements;
• Quicker and more case resolutions prior to trial;
• Reduction in needless delays in case processing;
• Integrated online information sharing (e.g. e-discovery exchange);
• Many can access a digital file at the same time.

We model these style of improvements as a reduction in the number of court visits required to resolve detainees’ cases. Specifically, we say that improvements reduce the number of court visits by $n$. Detainees’ court visits are reduced by the interarrival time of their removed court visits, $\xi_j, j = 1, ..., n$ down to a minimum of 30 days (we do not suppose that these improvements can shorten a case to less than a month). That is, we delete their first $n$ court visits. If a case was already shorter than 30 days, their case length is unaffected.

These improvements to the court system will be effective if detainees choose to not delay, so we modify their non-delaying case length distribution in the following manner: $\tilde{w} = max(30, w - \sum_{j=1}^{n} \xi_j)$ for all case lengths $w$. We refer to this new distribution as $\tilde{F}_N$. Their delaying case length distribution, $F_D$ remains unaffected. Note that this is a conservative analysis: improvements to the court system may have some impact on detainees’ ability to delay. As such our analysis provides a lower bound on the effects of reducing case lengths. We simulate detainee’s choice to delay or not, drawing their location costs from our estimates in Section 7. Depending on their choice, we draw their case length from $\tilde{F}_N$ or $F_D$.

For the non-delaying detainees, we simply reduce their case length by $\sum_{j=1}^{n} \xi_j$, down to a minimum of 30 days. If their case length was less than 30 days, it remains unaffected.

The plots in Figure 12 show the resultant drop in jail and EM populations from removing detainees’ first $n$ court visits. While Figures 12a and 12b seem seasonal and non-stationary, it is because we only consider detainees detained in 2015 and 2016. If we included all detainees, the population would look more like Figures 12c and 12d over the entire time range.
Figure 12  Reductions in Jail and EM Populations Over Time via Reduced Court Visits. Focusing attention on detainees who entered CCSO custody during 2015-2016, Figures 12a and 12b display the average predicted detainee populations over time. The detained population achieves steady state between September 2015 and December 2016. The vertical grey lines highlight this region. Figures 12c and 12d display this region in isolation for clarity.

Figure 13 displays the overall reduction as well as that for each crime class both for jail and EM populations.\textsuperscript{10} It shows that even a moderate reduction in the number of court visits results in significant reductions in both the jail and EM populations. At only one court visit reduced, the jail population is reduced by 4.84\% on average in steady state, and 5.22\% for EM.\textsuperscript{11}

\textsuperscript{10} We focused attention on the dates highlighted in Figures 12c and 12d in order to capture the steady-state effects. However, the broader date range portrayed in Figures 12a and 12b yield similar results.

\textsuperscript{11} Note that the magnitude of the change for EM is larger, despite people on EM having slightly longer cases if crime class is fixed. This is because the interarrivel times of court visits can be slightly longer for detainees on EM, and that the proportion of less-severe cases is larger for detainees who are qualified to be released on EM. The more severe, longer cases tend to be for detainees who are detained in jail.
Figure 13  **Average Reductions in Detainee Populations in Steady State via Reduced Court Visits.** These plots show the average reduction in jail (Figure 13a) and EM (Figure 13b) populations due to reduced court visits during the steady state period between September 2015 and December 2016. “Overall” provides statistics for all data. The remaining provide statistics by crime class.

These improvements are impactful for reducing the turnarounds population. Table 8 displays the benefits of reducing the number of court visits for the turnarounds population. Removing one court visit per detainee would cut turnarounds by 10.9%. This benefit would be associated with 29.8 years worth of reduced dead days each year, saving the jail $1.6 million in excess housing costs per year.

<table>
<thead>
<tr>
<th>Number of Court Visits Removed</th>
<th>Turnarounds (Net)</th>
<th>Turnarounds (Percent)</th>
<th>Excess Housing “Dead Days” (Years)</th>
<th>Excess Jail Housing Costs Due to Turnarounds (Millions of Dollars)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>244.0</td>
<td>10.9%</td>
<td>29.8</td>
<td>$1.6</td>
</tr>
<tr>
<td>2</td>
<td>347.4</td>
<td>15.5%</td>
<td>62.9</td>
<td>$3.3</td>
</tr>
<tr>
<td>3</td>
<td>437.5</td>
<td>19.5%</td>
<td>92.9</td>
<td>$4.9</td>
</tr>
<tr>
<td>4</td>
<td>517.9</td>
<td>23.1%</td>
<td>125.5</td>
<td>$6.6</td>
</tr>
<tr>
<td>5</td>
<td>575.0</td>
<td>25.6%</td>
<td>145.8</td>
<td>$7.6</td>
</tr>
</tbody>
</table>

Table 8  **Reduction in Turnarounds due to Reduced Court Visits.**

These reductions come with significant cost savings. Housing detainees in jail pretrial is expensive: $143 per inmate per day (Board of Commissioners of Cook County 2021). Thus, the aforementioned reductions in jail populations also substantially reduces costs. For a single court visit removed from detainees’ cases, Cook County would see a reduction of 413.5 years of total jail time served. This would achieve a cost savings of $20.1 million from housing costs every year (see Table 9 for estimated
Table 9  Yearly Case Length, Incarceration Time, and Cost Reductions due to Reduced Court Visits.

<table>
<thead>
<tr>
<th>Number of Court Visits Removed</th>
<th>Yearly Reductions in:</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Case Length EM (Years)</td>
<td>Case Lengths Jail (Years)</td>
<td>Total Jail Time Served (Years)</td>
<td>Jail Housing Costs (Millions of Dollars)</td>
</tr>
<tr>
<td>1</td>
<td>92.9</td>
<td>413.5</td>
<td>385.6</td>
<td>$20.1</td>
</tr>
<tr>
<td>2</td>
<td>198.7</td>
<td>826.7</td>
<td>785.8</td>
<td>$41.0</td>
</tr>
<tr>
<td>3</td>
<td>311.0</td>
<td>1252.8</td>
<td>1202.1</td>
<td>$62.7</td>
</tr>
<tr>
<td>4</td>
<td>409.6</td>
<td>1624.9</td>
<td>1566.9</td>
<td>$81.7</td>
</tr>
<tr>
<td>5</td>
<td>500.7</td>
<td>1940.0</td>
<td>1876.0</td>
<td>$97.9</td>
</tr>
</tbody>
</table>

Table 9  Yearly Case Length, Incarceration Time, and Cost Reductions due to Reduced Court Visits.

housing cost savings for 1-5 court visits removed). And, because the courts are overloaded, even modest reductions in the detainee’s number of court visits could have major operational improvements and cost savings there as well.

Our analysis is conservative in that we assume these improvements do not affect the detainees’ ability to delay. That is, we draw their case lengths from the original $F_D$ distribution estimated in Section 5 if they choose to delay. This underestimates the reductions associated with this policy. And because turnarounds often arise from delaying behavior, this underestimation is particularly acute for that population. To see how changes in incentive structure affect both the turnarounds population and the detained population at-large, see the counterfactual analysis in Sections 8.3 and 8.4.

8.2. Paying Bonds of Lower Level Detainees

The cost of pretrial detention in jail far exceeds the cost of paying for detainee’s bonds. Figure 14 displays CDFs of detainee detention costs grouped by the twelve most common “effective bonds,” the amount necessary for the detainee to be released. Nearly all detainees with small (yet common) bonds, such as $100 or $200, are more expensive to house than their bond. But even for groups of detainees with large effective bonds of $5,000 or $7,000, 40%-50% are more expensive to detain than their effective bonds. In every case, the mean cost to detain pretrial for the group is greater than the detainees’ effective bonds.

In this section, we consider how to pay bonds to reduce the number of detainees held in jail pretrial and analyze the associated cost savings. This policy considers all detainees held in jail, and is applied to subsets of those detainees if they meet the conditions of the policies described below. Suppose a third party (an NGO, Cook County, etc.) had a yearly budget of $d$ dollars with which to pay detainee’s bonds. This yearly budget can be thought of as renewing, a-la a county’s budget, or revolving due to people returning bails, a-la a revolving bail fund. In a more seasonal vein, charitable parties often pay some detainees’ bails near Christmas.\(^{12}\) If the party knew detainee’s case lengths a-priori, they could

Figure 14  Empirical CDFs of Pretrial Detention Costs by the Twelve Most Common Effective Bond Amounts. The black dashed line on each CDF represents the effective bond—the amount needed for detainee's of that group to be released. The orange dash-dotted line on each represents the groups’ mean costs to detain pretrial. The x-axis is truncated at $21,000 for readability.

maximize case length mitigated per dollar by prioritizing detainees by their “efficiency”: case length divided by effective bond. Unfortunately case lengths are not known a-priori. A suitable proxy for efficiency is to divide a detainee’s expected case length based on crime class (given in Table 10) by their effective bond. We deem this metric “approximate efficiency,” and make use of it in the policies below.

We display the results of two policies using these metrics in Figure 15. In both, we rank all detainees which enter the jail in a year by the associated metric: the “Oracle” policy ranks by efficiency, and the “Approximation” policy ranks by approximate efficiency. Then, detainees’ bonds are paid up to a budget \(d\) according to this ranking, the most efficient being paid first. In Figure 15a, we show that for a one million dollar yearly budget, the pretrial jail population would be reduced by 6.8% (Oracle)
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<table>
<thead>
<tr>
<th>Crime Class</th>
<th>Mean Case Length in Days</th>
</tr>
</thead>
<tbody>
<tr>
<td>M</td>
<td>512</td>
</tr>
<tr>
<td>X</td>
<td>201</td>
</tr>
<tr>
<td>1</td>
<td>117</td>
</tr>
<tr>
<td>2</td>
<td>126</td>
</tr>
<tr>
<td>3</td>
<td>88</td>
</tr>
<tr>
<td>4</td>
<td>47</td>
</tr>
<tr>
<td>A</td>
<td>19</td>
</tr>
<tr>
<td>B</td>
<td>13</td>
</tr>
<tr>
<td>C</td>
<td>12</td>
</tr>
</tbody>
</table>

Table 10  Mean Case Length in Days by Crime Class.

Figure 15  Jail Reductions with $d$ Yearly Budget. In each Figure, “Oracle” represents the policy prioritizing efficiency, while “Approximation” represents the policy prioritizing approximate efficiency. Figure 15a displays the average reduction in jail population in steady state. Figure 15b shows the mean yearly housing cost savings in steady state. For housing cost calculations, etainees who are released pretrial but are sentenced to jail are presumed to begin their sentence when their case ended before this counterfactual analysis.

and 2.5% (Approximation). Figure 15b displays the associated cost savings.\textsuperscript{13} A one million dollar per year budget would save Cook County an estimated $26 million under the Oracle policy and $10 million in the Approximate policy. Regardless of budget, reductions in the pretrial jail population and the associated savings are significant.

However, solely focusing on efficiency may release detainees deemed too severe. Detainees accused of class M felonies—first degree murders—rank highest in efficiency by a wide margin compared to other

\textsuperscript{13} Note that $143 per day per inmate is a lower bound on the cost of detaining people in the Cook County Jail. Special accommodations, mental disability, and more can increase the cost of detention in the jail (Board of Commissioners of Cook County 2021).
classes! (see Figure 16) It is necessary to consider policies which are implementable given information known at the outset of a case, and carefully weigh which detainees are eligible for release.

To that end, we consider five bond payment policies. For each, we consider all detainees who are detained in the jail in a year, but rank them differently. Their rankings are as follows:

- **“Lowest Class First”**: Pay bonds prioritizing lowest crime class first, then approximate efficiency.
- **“Approximation Class 1 or Less”**: Prioritize approximate efficiency, focus only on class 1 or less.
- **“Approximation Class 2 or Less”**: Prioritize approximate efficiency, focus only on class 2 or less.
- **“Approximation Class 3 or Less”**: Prioritize approximate efficiency, focus only on class 3 or less.
- **“Approximation Class 4 or Less”**: Prioritize approximate efficiency, focus only on class 4 or less.

Once ranked, detainees’ bonds are paid up to the budget $d$. This style of policy establishes a threshold of approximate efficiency above which people’s bonds are paid if they meet the restrictions of the policy. We plot the threshold in Figure 17b. Making use of this threshold allows for a straightforward heuristic to implement these policies in practice.

As seen in Figure 17a all three policies are effective at reducing the pretrial detention population. Using the “Approximation Class 3 or Less” policy with a budget of one million dollars results in a near 2% reduction in the pretrial jail population in steady state. At 2.5 million dollars, this reduction exceeds 3%. That is equivalent to a total of 320 years of time detainees would have been detained pretrial per year.

The savings in housing costs resulting from these policies is significant. Figure 18a displays these savings for the jail. For all policies and all budgets the savings in housing costs exceed the cost of paying bail. For all policies, a yearly budget of 1 million dollars would result in over 4 million dollars in savings for the Cook County jail. For the the policies which restrict based on maximum crime class,
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(a) Reduction in Pretrial Jail Population

(b) Approximate Efficiency Threshold over $d$

Figure 17 Results of Bond Payment Policies with $\$d$ Yearly Budget. Figure 17a displays the average reduction in jail population in steady state. Figure 17b shows the associated minimum approximate efficiency threshold used by each policy for each value of $d$.

The cost savings are nearly linear in the range we study. Thus, a dollar invested in paying bails under this policy results in a four- to six-fold savings in terms of housing costs. And this is a conservative estimate, as these policies focus on lower-level detainees.

Some detainees would have been sentenced to prison or jail following their trial, incurring housing costs during those periods. However, for detainees sentenced to supervision, or sentenced to probation, their post-sentencing cost to society is much lower. For detainees found not guilty, their costs are nonexistent. In Figure 18b, we show housing cost savings, presuming that detention costs in prison are equal to that of jail, and that supervision, probation, and “Charge Dropped or Finding of Not Guilty” have a cost of zero. Bond payments policies are highly effective on returns to society, returning nearly $4 million in housing costs for $1 million in paid bonds.

Pretrial release is studied by Usta and Wein (2015) within the Los Angeles criminal justice system. They create a model of the jail and courts system, and estimate the flows into, between, and from each element of that system. They find that pretrial release is not as efficient as split sentencing policy when evaluated on a metric of mitigated time served pretrial vs. risk of recidivism when calibrated to the data of Los Angeles. We do not have the necessary data available, namely an equivalent to the California Static Risk Assessment tool, to repeat their analysis and judge its appropriateness for the Chicago setting. However, we find that pretrial release can be an effective cost saving measure. And, the policies we suggest prioritize small bonds and low-level crimes first, which reduces recidivism risk. Our analysis of split sentencing, the policy Usta and Wein (2015) deem more effective for Los Angeles, is given in Section 8.3. We find it to be a powerful cost-saving tool, in line with Usta and Wein (2015).
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Figure 18 Cost Savings with $d$ Yearly Budget. Figure 18a shows the mean yearly housing cost savings in steady state for the jail. Figure 18b displays the reduction in housing costs to the taxpayer, presuming prison housing costs are equal to jail, and supervision and probation cost zero.

8.3. Split Sentencing

An “x-split sentence” divides a detainee’s total sentence duration s between incarceration (in jail or prison) and release (on supervision and/or probation). The parameter x represents the fraction of the detainees’ sentence which is dismissed. Thus, a detainee with a split sentence first spends their case length w in their pretrial housing location. Then, they spend any remaining jail or prison time, \((1 - x)s - w\), in that location. Finally, they are released to supervision or probation.

As with our model of detainee costs in Equation (1), with split sentences, detainees may choose to delay or not. We assume detainees don’t incur any costs after they are released. That is, the cost associated with supervision and probation are zero. Thus, for an x-split sentence, detainee i’s costs are given by:

\[ C_i(A) = c_i(l_1^i)E_A[W_i] + c_i(l_2^i)E_A[(1 - x)s_i - W_i]^+, \]

where expectations are taken under \(F_N\) and \(F_D\) as before and \(l_1^i\) and \(l_2^i\) are their phase 1 and 2 housing locations.

Because detainee’s sentences are released for part of their sentence, federal sentencing guidelines restrict eligibility for split sentencing to detainee’s whose charge and criminal history are not too severe. Specifically, split sentencing is only available to detainees who fall into Zone C or below of the Federal Sentencing Table (U.S. Sentencing Comm’n 2018), which is reproduced in Appendix E, Figure 21. Detainees in this zone have a maximum sentence of 18 months (prior to the application of any credit

14 The detainee’s credit time for pretrial detention counts toward their sentence duration, first reducing any time they must spend incarcerated, then reducing any remaining time they would be monitored on release.
time). We use this threshold to determine whether detainees are eligible for split sentencing when evaluating its effects.

We evaluate how offering various levels of split sentences to the eligible detainee population affects the EM and jail population.\textsuperscript{15} The detainees eligible for this sentencing policy are detainees whose sentence includes incarceration (jail and prison) and whose original sentence duration is 18 months or less. We draw detainees’ location costs using the structural parameters estimated in Section 7, and calculate their costs for delaying and not delaying. They choose the option which has the lowest cost. If they choose to delay, their case length is drawn from $F_D$. Otherwise, it is drawn from $F_N$.\textsuperscript{16}

<table>
<thead>
<tr>
<th>$x$</th>
<th>Case Length EM (Years)</th>
<th>Case Length Jail (Years)</th>
<th>Court Visits</th>
<th>Jail Sentences (Years)</th>
<th>Prison Sentences (Years)</th>
<th>Detention Costs in Jail (Millions of Dollars)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.1</td>
<td>34.7</td>
<td>23.9</td>
<td>764</td>
<td>25.2</td>
<td>144.3</td>
<td>$2.6</td>
</tr>
<tr>
<td>0.2</td>
<td>72.0</td>
<td>42.3</td>
<td>1490</td>
<td>46.2</td>
<td>285.1</td>
<td>$4.6</td>
</tr>
<tr>
<td>0.3</td>
<td>106.9</td>
<td>52.9</td>
<td>2084</td>
<td>65.1</td>
<td>421.6</td>
<td>$6.2</td>
</tr>
<tr>
<td>0.4</td>
<td>137.3</td>
<td>62.1</td>
<td>2600</td>
<td>82.4</td>
<td>547.5</td>
<td>$7.5</td>
</tr>
<tr>
<td>0.5</td>
<td>158.0</td>
<td>64.7</td>
<td>2903</td>
<td>97.5</td>
<td>661.7</td>
<td>$8.5</td>
</tr>
<tr>
<td>0.6</td>
<td>170.4</td>
<td>64.4</td>
<td>3061</td>
<td>110.5</td>
<td>760.1</td>
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</tr>
<tr>
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</tr>
<tr>
<td>0.8</td>
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<td>65.8</td>
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<td>128.4</td>
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</tr>
<tr>
<td>0.9</td>
<td>173.4</td>
<td>66.0</td>
<td>3121</td>
<td>133.0</td>
<td>932.9</td>
<td>$10.4</td>
</tr>
</tbody>
</table>

Table 11 Yearly Benefits from Split Sentencing. Case length is the yearly total of time people are detained in jail or on EM pretrial. Court visits are assumed to be spaced 28 days apart during the detainees’ pretrial detention. Jail and prison sentence time represent the yearly reduced total time people would be incarcerated in those locations due to their sentence being split. Finally, housing costs in jail incorporate reductions in both pretrial case length and reduced jail time.

*Post-Sentencing Effects.* Split sentencing reduces detainees’ sentence durations by a factor of $x$. These post-sentencing reductions, parameterized by $x$, are given in the columns “Jail Sentences” and “Prison Sentences” of Table 11. The reductions are presented yearly, so for $x = 0.5$, 97.5 detainee post-sentencing detention years would be removed from the jail each year. For the same $x$, 661.7 detainee years would be removed from the prison each year.\textsuperscript{17} The associated housing cost savings for the prison, if similar to that of jail, would be approximately $34.5 million annually. The entirety of the

\textsuperscript{15} The Sentencing Guidelines suggest that no more than half of the sentence be split to release (U.S. Sentencing Comm’n 2018) (i.e. $x$ should be less than 0.5). We will vary $x$ more broadly, across the full range of (0,1), to more completely evaluate split sentencing’s impact.

\textsuperscript{16} We assume that cases which resolved in 60 days or less are not likely to have delayed, and consequently their case lengths do not change. However, their sentence is still split according to $x$.

\textsuperscript{17} While we do not study the prison population, its population would also be reduced due to this decrease in total post-sentencing incarceration time.
reduction for prison is due to this post-sentencing effect. For jail, post-sentencing effects account for about 60% of the reduction in jail detention time.

**Pretrial Effects.** Detainees delay less often when offered split sentences, which reduces aggregate pretrial detention time. Yearly pretrial case length reductions for EM and jail are given in the columns “Case Length EM” and “Case Length Jail” in Table 11. For \( x = 0.5 \), EM and Jail detention time would be reduced by 158.0 and 64.7 detainee years each year. Pretrial effects account for all of the reduction in EM incarceration time and approximately 40% of the reduction in jail time. In total, these pretrial reductions can reduce the load on the courts system significantly. For \( x = 0.5 \), court visits would be reduced by 2903 each year.

**Outcomes on the Detained Populations.** The plots in Figure 19 show the resultant drop in jail and EM populations from offering split sentencing to eligible detainees for various values of \( x \). The average reduction in jail and EM populations during the steady state period are plotted in Figures 20a and 20b.

Offering split sentencing significantly reduces the jail and EM populations. At \( x = 0.5 \), the jail population is reduced by 2.73% and EM is reduced by 5.68%, see Figures 20a and 20b. The reductions in the jail and EM populations are most significant for low level crimes—classes 4, 3, and A. This targeted effect is due to the restrictions on split sentencing, not affecting detainees whose sentence represents a crime which is too severe. Reductions in the jail population directly reduce housing costs. At \( x = 0.5 \), the Cook County Jail could save $8.5 million per year.

These benefits are substantial across a wide range of \( x \) values. However, most of the effects are seen once the detainees’ sentences are mitigated by half (\( x = 0.5 \)), and generally have diminishing returns after this point. This suggests that feasible applications of split sentencing which are well within the U.S. Sentencing Guidelines can realize most of its benefits.

**The Impact of Split Sentencing on Turnarounds.** Split sentencing reduces delaying behavior and thus detainees’ case lengths. When measured against their original sentences, this reduces turnarounds; see Table 12. For example, for \( x = 0.5 \), turnarounds would be reduced by 12.6%, with an annual reduction of 124.9 years worth of dead days and $6.5 million of housing costs during that time. But split sentencing reduces the incarceration portion of detainees’ sentences. Measured against this new sentence duration, \((1 - x)s\), this policy creates “new turnarounds,” those who are incarcerated in jail longer than their split sentence would require. Table 13 reports these increases. Splitting sentences by half, \( x = 0.5 \), would create 2006.3 additional new turnarounds each year, a 98.4% increase. Measured

\( ^{18} \) As before, because we consider detainees who enter CCSO custody in 2015-2016, these appear non-stationary, but the detained population achieves a steady state in the period shown in Figures 19c and 19d. Implementation of this policy would resemble this steady state period.
Figure 19  Reductions in Jail and EM Populations Over Time via Split Sentencing.

Focusing attention on detainees who entered CCSO custody during 2015-2016, Figures 19a and 19b display the average predicted detainee populations over time. Only eligible detainees were offered split sentencing, other detainee’s cases were unchanged. The detained population achieves steady state between September 2015 and December 2016. The vertical grey lines highlight this region. Figures 19c and 19d display this region in isolation for clarity.

against the detention portion of their sentences, this would make 946.7 years worth of new dead days per year. The cost associated with that time would be $49.4 million.

Detainees, in general, would be better off with this policy because of shorter case lengths and less costly sentences. The jail would also save money. But it would increase instances that people are detained longer than their required detention time, precisely because their required detention time is reduced. To avoid this, split sentencing should be applied in tandem with operational improvements which reduce case lengths.
Ata and Hannigan: Pretrial Detention at the Cook County Jail

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(a) Average Reductions in Jail Population  (b) Average Reductions in EM Population

Figure 20 Average Reductions in Detainee Populations in Steady State via Split Sentencing. These plot the average reduction in jail (Figure 20a) and EM (Figure 20b) populations due to reduced court visits during the steady state period between September 2015 and December 2016. “Overall” provides statistics for all data. The remaining provide statistics by crime class. Classes X and M are excluded because they are unaffected by the policy. Classes B and C are excluded from the figure as they represent very few detainees in the data.

<table>
<thead>
<tr>
<th>Yearly Reductions in:</th>
<th>Turnarounds (Net)</th>
<th>Turnarounds (Percent)</th>
<th>Excess Housing Time “Dead Days” (Years)</th>
<th>Excess Jail Housing Costs Due to Turnarounds (Millions of Dollars)</th>
</tr>
</thead>
<tbody>
<tr>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.1</td>
<td>72.0</td>
<td>3.5%</td>
<td>33.8</td>
<td>$1.8</td>
</tr>
<tr>
<td>0.2</td>
<td>136.3</td>
<td>6.7%</td>
<td>67.1</td>
<td>$3.5</td>
</tr>
<tr>
<td>0.3</td>
<td>189.8</td>
<td>9.3%</td>
<td>92.4</td>
<td>$4.8</td>
</tr>
<tr>
<td>0.4</td>
<td>233.7</td>
<td>11.5%</td>
<td>112.8</td>
<td>$5.9</td>
</tr>
<tr>
<td>0.5</td>
<td>257.9</td>
<td>12.6%</td>
<td>124.9</td>
<td>$6.5</td>
</tr>
<tr>
<td>0.6</td>
<td>272.9</td>
<td>13.4%</td>
<td>129.9</td>
<td>$6.8</td>
</tr>
<tr>
<td>0.7</td>
<td>275.7</td>
<td>13.5%</td>
<td>133.7</td>
<td>$7.0</td>
</tr>
<tr>
<td>0.8</td>
<td>277.1</td>
<td>13.6%</td>
<td>133.1</td>
<td>$6.9</td>
</tr>
<tr>
<td>0.9</td>
<td>276.8</td>
<td>13.6%</td>
<td>132.7</td>
<td>$6.9</td>
</tr>
</tbody>
</table>

Table 12 Reduction in Turnarounds due to Split Sentencing Using Old Sentences as Metric. Here, to determine whether or not someone is a turnaround, we use their original sentence duration, pre split-sentence.

8.4. Reducing the Relative Cost of Imprisonment

As discussed above, delaying behavior is largely driven by the high cost of prison relative to jail. To reduce it and increase social welfare, we consider policies which may reduce the relative cost of prison
to jail, and explore how that may effect pretrial detention. To compare dollars-to-dollars, we estimate society’s cost for being housed in prison using payouts for wrongful imprisonment from the state.

Prison’s perceived cost per unit time could be lowered relative to jail in quite a few ways. For example:

1. **Subsidize family visits to prison.** Some defendants may prefer jail to prison because the Cook County Jail is located within the city, while prison is located far outside of the city. Consequently, family visits are possible in jail but not as easily in prison. If this changed, people may be more willing to serve their time in prison.

2. **Ensure quality living conditions in prison.** Living conditions in prison may need to be improved. As a result, fewer people would avoid it.

3. **Promote prison-oriented educational/remedial opportunities which aren’t available in jail.** If there are educational opportunities in prison rather than jail (or more in prison than in jail), some people who suspect that they will get a prison sentence will opt to serve it there so they can get the benefit of the opportunities there. This has the additional benefit that prison sentences have definite beginning and end dates, allowing for more structured educational programs.19

To assign a dollar cost to prison, we consider payments from the state for wrongful imprisonment. As a conservative estimate, Illinois law stipulates that people wrongfully detained in prison for 5 years or less can be awarded up to $85,350, fourteen years or less can be awarded $170,000, and more than fourteen years can be awarded $199,150.20 These adjust with cost of living increases, and include some

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19 Educational programs exist within prisons at the moment and detainees can earn credit against their sentence for participating in them.

additional funds for attorney fees, education, and job placement assistance. Federal guidelines suggest a higher rate of pay of $63,000 per year imprisoned, with an additional $63,000 for each year on death row.\(^\text{21}\) Awarded amounts can be higher. For example, in 2020, three men were awarded approximately $280,000 per year of wrongful imprisonment.\(^\text{22}\) In 2011, DNA tests exonerated five men who were awarded approximately $400,000 per year for nearly 20 years of wrongful imprisonment, totaling $40 million in their joint-wrongful conviction settlement.\(^\text{23}\)

To model the social welfare gained from reducing the relative cost of prison, we make use of the costs listed above. We consider three different dollar-equivalent costs for time in prison: $14,285 per year (“Low”—Illinois’ payout rate), $63,000 per year (“Medium”—the Federal payout rate), and $400,000 per year (“High”—a representative large payout awarded to wrongfully imprisoned detainees). Costs for other housing location are scaled at the same proportion as the mean estimated costs in Section 7. That is, EM is 0.370/1.835 times less costly than prison, and jail is 1.378/1.835 times less costly than prison. We model the effect of the policies as reducing the mean cost of prison either halfway to that of jail, or entirely to that of jail. Then, in light of these reduced costs, we simulate detainee behavior to evaluate the effect on the criminal justice system.

<table>
<thead>
<tr>
<th>Cost Reduced to</th>
<th>Total Yearly Reductions in:</th>
<th></th>
<th>Jail Case Length</th>
<th>EM Case Length</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Case Lengths (Years)</td>
<td>Court Visits</td>
<td>Case Length</td>
<td>Case Length</td>
</tr>
<tr>
<td>Jail</td>
<td>193.5</td>
<td>2523</td>
<td>155.4</td>
<td>38.1</td>
</tr>
<tr>
<td>Halfway to Jail</td>
<td>96.6</td>
<td>1260</td>
<td>81.0</td>
<td>15.6</td>
</tr>
</tbody>
</table>

Table 14 Yearly Detention Time Reductions due to Prison Cost Reduction. Case length is the yearly total of time people are detained in jail or on EM pretrial. Court visits are assumed to be spaced 28 days apart during the detainees’ pretrial detention. Jail and prison sentence time represent the yearly reduced total time people would be incarcerated in those locations. Note that a negative value indicates an increase in that statistic.

Reducing the perceived cost of prison reduces delaying behavior. This shortens case lengths, as seen in Table 14. By reducing the cost of prison to be (on average) equal to the cost of jail, case lengths would be reduced by 193.5 years annually, and the total number of annual court visits by approximately 2523. The majority of this contribution comes from people detained in jail pretrial whose incentive to delay was reduced. These case length reductions pair with significant reductions in the overall jail


and EM populations. By reducing the cost of prison to jail (halfway to jail), in steady state the jail population would be reduced by 2.00% (1.05%) and the EM population by 1.51% (0.65%). Note that for people sentenced to prison, a reduction in case length results in a commensurate increase in prison time. We find that this increase in time would be 129 years and 64 years annually for a reduction in prison cost all the way to jail and halfway to jail respectively.

<table>
<thead>
<tr>
<th>Total Yearly Reductions in:</th>
<th>Cost Reduced to</th>
<th>Turnarounds ( # People)</th>
<th>Percent of Turnarounds</th>
<th>Dead Years</th>
<th>Housing Costs (Millions of Dollars)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Jail</td>
<td>932</td>
<td>41.5%</td>
<td>63.6</td>
<td>$3.3</td>
</tr>
<tr>
<td></td>
<td>Halfway to Jail</td>
<td>859</td>
<td>38.2%</td>
<td>32.5</td>
<td>$1.7</td>
</tr>
</tbody>
</table>

Table 15 Yearly Turnaround Reductions due to Prison Cost Reduction.

The reduced delaying behavior also significantly reduces turnarounds. Turnarounds would be reduced by 38.2% by reducing prison costs halfway to that of jail, and 41.5% by reducing them to be equal to that of jail. Their associated dead days would be also reduced. By reducing the cost of prison to that of jail, there would be an associated annual savings of $3.3 million in housing costs from dead days, and 63.6 years of dead days annually.

These reductions in (perceived) housing costs also increase social welfare. We display the change in perceived costs for people detained by the Cook County Sheriff’s Office Table 16. As shown in the table, reducing the cost of prison to be equal to that of jail could, with a conservative estimate, reduce annual perceived detention costs by $11.9 million across detainees. At the high end, this could amount to over $335.5 million. Note that while we do not have data on people in prison who were not detained by the CCSO, these changes would effect them as well, and so these benefits are a conservative estimate.

<table>
<thead>
<tr>
<th>Total Yearly Reductions in:</th>
<th>Cost Reduced to</th>
<th>Disutility $14,285/year (Millions of Dollars)</th>
<th>Disutility $63,000/year (Millions of Dollars)</th>
<th>Disutility $400,000/year (Millions of Dollars)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Jail</td>
<td>$11.9</td>
<td>$52.4</td>
<td>$335.5</td>
</tr>
<tr>
<td></td>
<td>Halfway to Jail</td>
<td>$6.0</td>
<td>$26.6</td>
<td>$169.0</td>
</tr>
</tbody>
</table>

Table 16 Yearly Dollar-Equivalent Disutility Reductions due to Prison Cost Reduction. Note that these estimates are only for people detained by the CCSO.

Our results suggest that changes to prisons which lower their perceived detention cost could have significant positive effects for society. In the practical sense, delaying behavior and pretrial case lengths could be decreased, and as a result, housing costs and court cost would be decreased. Additionally, by incorporating detainee preferences, social welfare could be increased.
9. Conclusion

This paper is concerned with delays that cause excessively long pretrial detention in the Cook County Jail. This detention wastes detainees’ time, cost taxpayers money, and burden the courts system.

In Section 6 we introduce a model of detainee behavior where they can choose between two actions: delaying or not. In doing so, they can shift their expected balance of incarcerated time between their pre-trial detention location and their post-sentencing detention location. Then, by observing the detainee’s realized case lengths, we estimate the structural parameters of their location costs. We estimate that within the population, prison is perceived as the most costly housing location with a mean cost of 1.732. Jail is slightly lower on average, with a mean cost of 1.301. And, as is intuitive, EM is the least costly, with a mean of 0.349. We make use of these estimates to evaluate different counterfactual policies on the Cook County Jail.

First, we consider the effect of improvements to the Cook County courts system. By reducing the required number of court visits to adjudicate detainees cases by one, we estimate that the jail could save $20.1 million in housing costs each year due to 385.6 fewer detainee years spent in jail each year. These improvements also significantly impact the turnarounds population—one fewer court visit could remove 44.8% of turnarounds. These results suggest that improving the courts system is an extremely valuable lever to tackle the problems associated with pretrial detention. Future work in this area could explore the drivers of court delays to uncover further operational improvements to the courts, and associate a cost with these improvements. Furthermore, the courts are overloaded; a deeper understanding of how marginal improvements to the courts could create outsized impacts on load could be useful, as even small gains in efficiency have large impacts on the jail population.

Second, we show that paying people’s bonds using an easy-to-implement prioritization scheme can save the jail four times what the policy costs by targeting the lowest-level offenders. Bond-payment policies are an intriguing area for future research. Our model establishes a threshold policy which is simple to implement. However, more complex fund-allocation policies could improve efficiency and save costs. In a similar setting, Usta and Wein (2015) evaluate detailed risk assessment policies for pretrial release. We do not capture this explicitly, and it is a great element which deserves future attention.

Third, we analyze split sentencing. We estimate that it can reduce the load on the courts system, and, by reducing detainees’ required sentence time, can also significantly reduces incarceration costs overall. However, this policy should be implemented with turnarounds in mind: as sentences get cut between incarceration and release, a significant portion of detainees will have case lengths which exceed their necessary incarceration time. To avoid this, split sentencing should be implemented in tandem with improvements to case processing speeds.

Finally, we study the impact of reducing the cost of detention in prison. We find that there are multiple benefits of doing so. Speedier case resolutions from reduced delaying behavior would reduce pretrial detention time, turnarounds, and court visits. Increases to social welfare would also be significant.
10. Acknowledgments

We are grateful to the Cook County Sheriff’s Office for their support. We also thank Allie Cox, Hussain Khan, and Will Murphy for insightful discussions about court proceedings and the perspective of public defenders in the criminal justice system. Finally, we are grateful to the Rustandy Center at Chicago Booth and especially to Salma Nassar for her outstanding support during various stages of this work.

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### Appendix A: Credit Days

Detainees in jail or on EM accumulate credit time which counts against their sentence duration. There are three main ways of getting credit time, Statutory Sentence Credit, Program Sentence Credit, and Supplemental Sentence Credit.\(^24\)

Statutory Sentence Credit reduces the percentage of their sentence detainees must serve based on the severity of the crime. Common percentages are 50%, 75%, 85%, or 100%. These percentages are determined by statute and by judge: different crimes have their minimum percentage of time served enumerated in law, and judges can increase the required percentage on a case-by-case basis. Detainees may lose this credit due to negative behavior while in custody.

Program Sentence Credit is credit for participating in certain programs while in jail or prison. Common programs are for education, drug rehab, life skills courses, behavioral modification, re-entry planning, and Illinois correctional industries. If an detainee participates, they earn a half of a day per day in program, conditional on completing the program. Not everyone is eligible for this program, and detainees can lose this credit due to bad behavior.

Finally, Supplemental Sentence Credit gives up to 180 days of credit for good behavior in prison, and is the sole discretion of the Director of Department of Corrections.

### Appendix B: Appendix: Speedy Trial Act

Defendants’ rights to a speedy trial are ensconced in the sixth amendment: “In all criminal prosecutions, the accused shall enjoy the right to a speedy and public trial.” And in Illinois, the legislature has also

\(^24\)https://www2.illinois.gov/idoc/aboutus/Pages/faq.aspx#qst1 Accessed on 10/18/2021.
guaranteed this right by statute with the “Speedy Trial Act” (725 ILCS 5/103-5). This act establishes a time limit for cases. After that time is expired, defendants may call for an immediate trial.

For defendants who are released on bail the limit is 160 days. For detainees on CCSO custody, the limit is 120 days. However, “Delays occasioned by the defendant” do not contribute to the 120- or 160-day speedy trial act clock. Any pretrial motion filed by the defendant (such as requests for information) is a delay occasioned by the defendant. The time the motion takes to resolve does not contribute to the speedy trial clock. “Agreement continuances” also count as delays occasioned by the defendant. Most often, these come from pretrial negotiations between the prosecution and defense. They may involve plea negotiations, witness availability, trial stipulations, and other things which take time. During these negotiations, the prosecution and defense meet with a judge to update them about the case and continue the case to complete these negotiations.

Appendix C: Hyperparameter Selection for SAR-EM Algorithm

We tested the panel of models and hyperparameters outlined in Table 17. We also varied the propensity score decay parameter $d$ in $\{.5, .6, .7, .9, 1\}$. To do so, we split our data into a training set and a test set, following (Lee and Liu 2003), accounting for 80% and 20% of the overall data, respectively. Within this split, we ensure that the same proportion of detainees were labeled positively in the train and test sets. We begin by training the models on the train set. Then, to evaluate the models, we use the trained models to classify the test set. The models are ranked by the maximum modified $F_1$ score they achieve on the test set, where a larger modified $F_1$ score indicates better performance. Once the best performing model and hyperparameter combination is selected, we train the best performing model on the entire dataset to classify the data for use in our model. Logistic regression performed best. Logistic regression is also used by Bekker and Davis (2018), as it is “known to predicted well-calibrated probabilities (Niculescu-Mizil and Caruana 2005)”.

25 That is, we separate positive and negative samples, then select 20% from each group to create the test set.
Appendix D: Monte Carlo Experiments

This section uses Monte Carlo experiments to evaluate the maximum likelihood estimation procedure described in Section 6 to identify true location cost parameters. We generate 100 datasets assuming the parameters listed in Table 7 are true, then estimate new parameters from the simulated data. We confirm that the true parameters fall within a 95% confidence interval of these estimates.

To simulate our data, we independently draw each detainee’s location costs assuming the true $\mu$ and $\sigma$ parameters for each location. Then, holding our estimates of the case length distributions $F_D$ and $F_N$ constant, we determine each detainee’s cost for delaying and not delaying using their cost function (Equation (1)). They choose the action with the lower cost. Using their housing location, crime class, and action, we draw their case length $w$ (with replacement) from the appropriate $F$. Finally, we re-estimate their location cost parameters, $\hat{\mu}$ and $\hat{\sigma}$, as before. We construct a 95% confidence interval by removing the upper and lower 2.5% of the re-estimated parameters. The true parameters and 95% confidence interval of the re-estimated parameters are listed in Table 18.

<table>
<thead>
<tr>
<th>Location</th>
<th>True $\mu$</th>
<th>95% CI</th>
<th>True $\sigma$</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>EM</td>
<td>0.370</td>
<td>[0.211, 0.457]</td>
<td>0.241</td>
<td>[0.138, 0.333]</td>
</tr>
<tr>
<td>Jail</td>
<td>1.378</td>
<td>[1.034, 1.614]</td>
<td>0.446</td>
<td>[0.365, 0.631]</td>
</tr>
<tr>
<td>Prison</td>
<td>1.835</td>
<td>[1.325, 2.024]</td>
<td>0.313</td>
<td>[0.107, 0.470]</td>
</tr>
</tbody>
</table>

Table 18 Results of Monte Carlo Experiments. The true parameters are the location cost parameters listed in Table 7. Each is presented alongside the associated 95% confidence interval of the re-estimated parameters from simulated data assuming these true parameters.
We observe that the true estimated parameters fall within the confidence interval for each location. This demonstrates that our estimation procedure can successfully recover the true structural parameters from the data.

Appendix E: Federal Sentencing Guidelines

Figure 21 is a reproduction of the Sentencing Table set forth in the U.S. Sentencing Guidelines §5A (U.S. Sentencing Comm’n 2018). These guidelines use “offense level”, which are a similar, but more granular classification of charges’ severity to Illinois’ crime classes. Higher offense levels indicate more serious charges.
Figure 21  United States Sentencing Table.