SPAC
Illinois Sentencing Policy Advisory Council

Prison Population Projection

Methods and Technical Description

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December 29, 2016

Overview

The Illinois Sentencing Policy Advisory Council (SPAC) is statutorily mandated to produce annual prison population projections to inform policymakers and the public of how the population is changing. Population projections are also a valuable tool for analyzing policy proposals that affect the sentenced population. With consistent calculations, projections help determine future impacts of proposed policy changes, including the cumulative impact of multiple policy changes. Population projection models are not meant to be crystal balls that predict the future with 100% accuracy. They are a statistical method to project likely outcomes by applying assumptions based on historical trends and expectations for future admissions and lengths of stay in prison.

This report explains the methodology and technical calculations of the SPAC projection model, providing details on the data and assumptions used, and a brief description of the model's limitations and next steps. The model is written in SQL and uses IDOC data from the current prison population file and three years of admissions data and applies a set of assumptions that remain constant to create an estimate of the future prison population. This method can also project subgroups, such as drug possession offenders or elderly offenders. The crux of the methodology is that the size of IDOC's prison population is determined by sentences imposed, prison admissions, and the length of time a person spends in prison. Policy changes can affect one or all of these factors, and the model will answer the baseline question – "what if we make this change?"

This model is the product of collaboration with a number of talented people. SPAC would like to thank them for their significant contributions to developing the model: Robert Minton, University of Chicago economics major who began work on this model as a student intern with SPAC; Lindsay Bostwick, a Ph.D. candidate at Carnegie Mellon University, whose insight informed the process of designing and testing the SPAC projection model;[1] Dr. Sharon Shipinski, Research Director for the Illinois Department of Corrections, an invaluable resource who consistently offers practical reality checks; Christine Devitt-Wesley and Ernst Melchior from the Illinois Criminal Justice Information Authority – their contribution to criminal justice research in this state is longstanding and outstanding. Additional thanks go to those individuals who vetted the model, tested its calculations, and offered valuable feedback from "fresh eyes": Peter Brown (Indiana University), Forest Gregg (DataMade), Dr. Megan Alderden (Illinois Criminal Justice Information Authority), Dr. Richard Gorvett (University of Illinois-Champaign/Urbana), Dr. David Olson (Loyola University-Chicago), and Dr. Bruce Spencer (Northwestern University).

The Fundamental Challenge for Projections

The fundamental challenge in projecting future impacts of policy proposals is that data on prison admissions and exits do not exist for future years. SPAC simulates the future data using a set of reasonable assumptions about admissions and length of stay. The assumption is that the recent past

[1] Lindsay Bostwick. Aug. 4, 2016. Reducing the Prison Population: Evidence from Pennsylvania. Retrieved from SSRN: https://ssrn.com/abstract=2861003.

approximates future admissions and lengths of stay. The recent past is defined as the average of the most recent three years data as its starting point, which allows all the results to be seen in the context of recent experience. This approach creates a baseline and then allows for SPAC to modify the inputs of admissions and length of stay. While the past is a good predictor of the future, unknown events or shifts can dramatically change the main inputs of length of stay and admissions, thus the fundamental challenge will always remain.

An example demonstrates the utility of the projection model: If a policy is enacted to reduce the length of stay for non-violent Class 4 offenders by 60 days, SPAC could simply remove 60 days from the length of stay for all future admissions for Class 4 non-violent offenses. Additional details could be incorporated, such as (1) adjusting the probability of getting the 60 day reduction, *i.e.*, only 50% of the eligible cohort receive the 60 day credit in the future; (2) setting floor restrictions, such as applying the 60 days only if the person's expected length of stay is greater than 60 days; and/or (3) other simulations. The end result can show a projected population compared to the baseline projection. The result allows for detailed analysis of the timing of the changes, the demographic impacts, and other population characteristics of interest. Future iterations of the model may improve projections, but the simple use of the past allows for a baseline that can be compared to "what if" scenario results.

The report describes the methodology in the following order:

- Model Projection Results
- Assumptions and Future Improvements
- Data Sources and Definitions
- Technical Calculations
    - Estimating Length of Stay
    - Estimating Future Admissions
    - Credit Adjustments

Model Projection Results

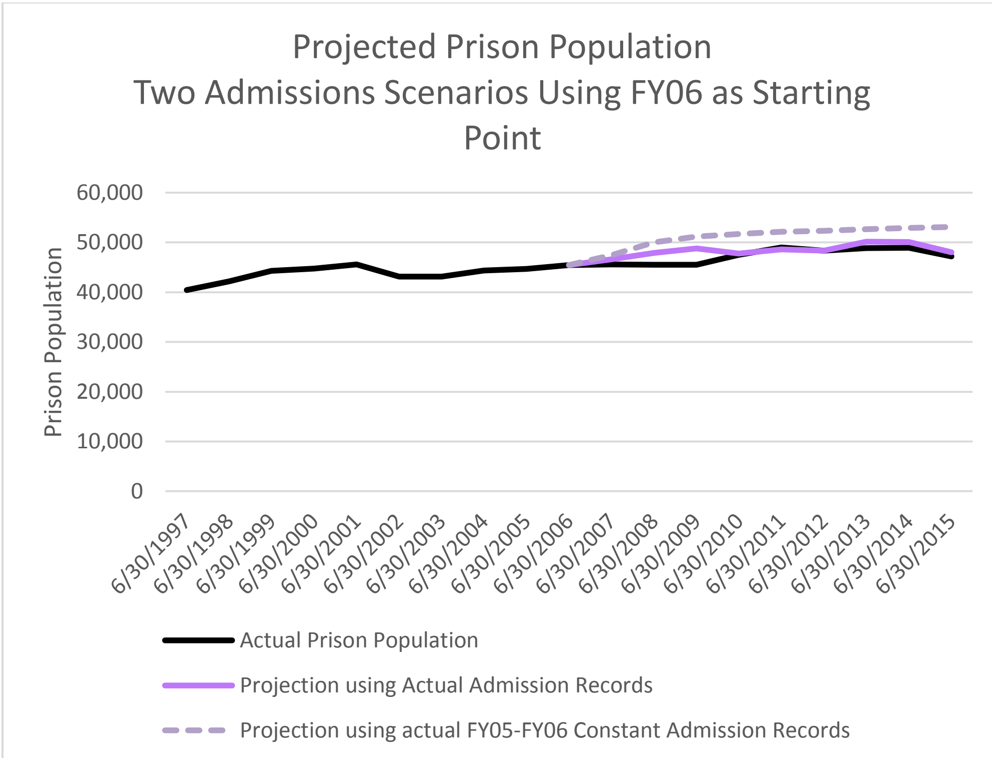
Results - Historical Performance

Before projecting forward from the present, SPAC tested the model's admissions assumptions by using the relevant data from 2004 through 2006 to simulate a projection of the 2016 prison population. The model's calculations are the same as the forward-looking projection but used historical data to test the methodology. Using the fiscal year 2006 prison population data as a starting point,[2] SPAC added the average admissions from the FY2005 and FY2006[3] for ten years until FY2015. The model overestimated the actual prison population by several thousand because between FY06 and FY15 admissions declined, fairly linearly, by over 25%. Therefore the model's assumption that admissions would remain constant and match the FY2005-06 admissions patterns did not occur and the 2016 population was overestimated. This result emphasizes the fundamental challenge in projections regarding the uncertainty of the future.[4]

[2] The State's fiscal year runs from July 1 through June 30, such that fiscal year (FY) 2006 begins July 1, 2005 and continues until June 30, 2006. The prison population for FY2006 is at the end of the year: June 30, 2006.

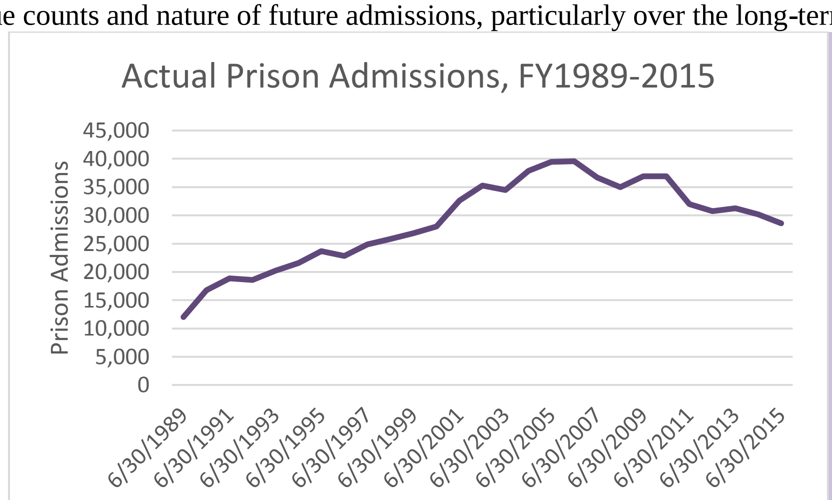
[3] Consecutive sentence data is limited prior to FY2005. As a result, for the historical check beginning with the FY2006 prison population, two instead of three prior years of admissions were used to simulate future admissions. Each admission was weighted by 1/2 instead of 1/3.

[4] SPAC plans to review options for improving the future admissions assumptions. However, holding the recent past constant has an added value of simplicity and understandability, despite having limitations on fully predictive or forecasting ability. Because this model is primarily a projection for "what if" scenarios, SPAC uses this simple assumption, which has been tested and vetted.



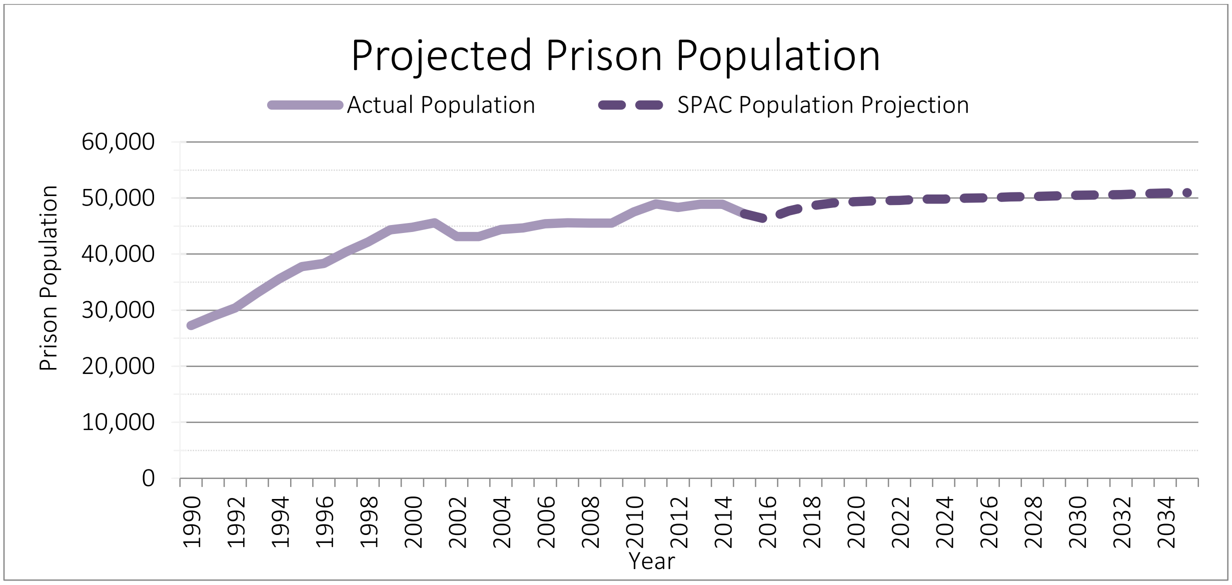
SPAC tested the model's length of stay approach by running the model using actual admissions records over this period but still estimating the length of stay for each admission. The simulation produced values much closer to the actual prison population count, with overall counts typically within 3% of the true population. This simulation is useful for checking if the model produces a prison population estimate if we knew the true future admissions.

Accurately forecasting future admissions is unlikely to occur. For example, on June 30, 2006, SPAC would have had to have assumed or estimated that admissions would fall steadily by roughly 25% over the next decade, even though there was at that time a consistent increase since at least FY1989. This example shows how the projection model should not be interpreted as a forecasting model simply because estimating the true counts and nature of future admissions, particularly over the long-term, is unrealistic.



Results - Future Status Quo Projection

SPAC projected the prison population for FY2016-2035 using the same calculations and assumptions mentioned above. The projection model projects the prison population to increase to around 50,000 by FY2025 and then to stay relatively flat with a slight annual increase occurring in the future. The assumption of constant admissions results in a projection with a fairly constant slope in the future. The model currently over-projects (at least in the short-term) due to assuming future admissions would look like the average admissions from FY2013-2015. In reality, prison admissions have continued to decline and the higher number of admissions in FY2013 and FY2014 cause the projection to be high. Several adjustments can remedy this overestimate if SPAC chooses to deviate from the constant admissions assumption (*i.e.*, assume a continual decrease in admissions).



Strengths of SPAC Projection

The SPAC prison population projection takes the two key policy levers—admissions and length of stay—to create a reasonable estimate of the State's future prison population. Both admissions and the average prison terms are held constant from the average of the past three years. This approach gives a plausible baseline to compare any simulated policy changes. The implicit assumptions are also familiar to system stakeholders—for example, if a reader believes admissions were abnormally low for the past three years, they can read the model's output as a conservative underestimate of the future prison population. Likewise, a reader who believes admissions will continue to fall can read the output as an overestimate of the future prison population. Both can understand the projection based on familiarity with past experience.

In 1987, George Box wrote, "Essentially, all models are wrong, but some are useful." SPAC offers this prison population projection as a model that can assist policymakers in understanding the levers for controlling the State's corrections system. This model has been carefully vetted and discussed with a variety of experts, including criminologists, prison administrators, computer scientists, and actuaries. Further, the technical descriptions below explain in detail how the projection calculations occur and any feedback or criticism can improve the model design in the future. If any updates are made to the model calculations, an update of this report will be published.

From the model's baseline estimate, SPAC can now demonstrate the relationship between the key policy levers and simulate changes in State policies and practices. For example, SPAC could estimate the effect of removing admissions for drug offenses, changing the sentences imposed, or sentence credit policies that lead to more or fewer early releases. Importantly, the model can also show the interaction between all three options and the cumulative effect of implementing multiple policy changes. "What if" scenarios can now be simulated, described, and incorporated into future policy discussions.

Assumptions and Future Improvements

The projections are a result of the assumptions on inputs. The main assumption for the model is that future admissions will, in quantity and quality, resemble the admissions in the past three years relative to when the projections are run. This is a big, but reasonable, assumption. Admission data will be updated annually. So, for example, when running projections in 2018, the admissions data used will be from FY2015-FY2017 instead of FY2013-FY2015.

SPAC believes the assumption is reasonable for two reasons: First, the model is not intended to supply a precise forecast (estimate where assumptions are expected to be correct), but instead a projection (estimate where assumptions are expected to be reasonable for purposes of modeling policy changes). Second, this assumption is reasonable for lack of other reliable data. If the past three years are not used for future baseline estimates, what alternative should be used? The use of a broader set of data, such as crime data or changing demographics, may lead to short-term improvements, but the underlying assumptions of future crime must still be made. Further, the elasticities between arrests, convictions, and prison sentences would need to remain stable over time, or the resulting inaccuracies could compound in the long-run projection and build the biases from the assumptions rather than improve accuracy. In the future, SPAC will consider making adjustments based on changing demographics and age profiles of the general population using public health and population census data for Illinois.

Feedback loops may also impact the model's ability to describe accurately the "what if" scenarios. For example, if drug possession admissions are no longer allowed in prison, some of those people who would have been admitted into prison on a drug offense will instead get probation, violate probation by committing a more serious property offense, and perhaps enter prison on that more severe offense. In this "what if" scenario, the drug possession admissions would decrease but, with a slight delay, admissions for other offenses may rise. The simulation model allows for SPAC to incorporate these feedback loops. The challenge will be to identify the feedback loop outputs and reasonably predict the timing, people affected, magnitude of the effect, and other interactions. These feedback loop mechanisms will be difficult to predict, although plausible simulations may give policymakers and stakeholders a better understanding of possible outcomes of policy change.

There are some data limitations for adjusting the lengths of stay for individuals currently in the prison population, particularly for consecutive sentences. Under the current model, only the most serious offense is considered when estimating length of stay adjustments and future admissions. Future iterations may take into account that a change in sentence for one offense may result in a different conviction becoming the most serious or change the likelihood of getting a prison sentence, which would decrease admissions. These complexities are important to consider for accuracy but are not likely to significantly alter the projection's results. SPAC intends to improve this issue in the future using additional data from Offender 360, the new IDOC record management system.

Data Source and Definitions

The source data were a major contributor to the model design, so understanding the data helps understand how the model works. The data for the projection are historical data from IDOC. Each year the IDOC Planning and Research Division shares event-level (prison admission, prison exit) files for the fiscal year prior and a snapshot of the prison population on two dates (June 30 and December 31). These files show the distribution of offense classes, age groups, lengths of stay, or other subgroup, over time. Based on past experience working with the data, as well as discussions with national researchers such as at the U.S. Bureau of Justice Statistics, the data are of high quality and sufficient for analysis.

Some terms that are used in the description of this model are as follows:

- *Prison admission*: The entry of a person into a prison facility. The entry can be the result of a court sentence or a technical violation of mandatory supervised release (MSR, or commonly referred to as parole) that does not have a new sentence at the time of the admission. A person can enter prison more than one time in any given year. Movements such as a return from work release, prison transfers, and court transfers are not included. For this file, the movements that are included originate from court or parole.
- *Prison exit*: The exit of a person from prison out to the community. Generally, all people who enter prison as a result of a sentence imposed will exit prison and be on mandatory supervised release. If the person was admitted as a technical violator, they may exit back onto parole if their sentence has not been fully discharged (completed), or be released without further supervision if their MSR term has expired. For this file, the movements that are included are from prison to the community regardless of admission type.
- *Sentence length*: The court imposed sentence term for a convicted individual. Offenders can have more than one sentence, and each sentence can be concurrent (served simultaneously) or consecutive (served sequentially). The minimum sentence to prison is one year and the maximum sentence can extend to or beyond the natural life of the offender.
- *Length of stay*: The actual length of stay in prison. In most cases, the length of stay will be less than the sentence term recorded at the time of admission. The length of stay will be shorter because of authorized sentence credits offenders can earn in prison that reduce their length of stay. Some offenders are prohibited from being awarded sentence credits, such as those sentenced to natural life, and those who serve under a truth in sentencing restriction on sentence credit. The focus for the projection model is the prison length of stay. Other lengths of stay (jail, parole) can be or are incorporated in the model, but are not of primary importance as an output.
- *Violent vs. non-violent crime*: A categorization of an offense based on the nature of the offense. SPAC categorized crimes as violent or non-violent based on Illinois Rights of Crime Victims and Witnesses Act (725 ILCS 120). This is just one of many possible classification methods, but is the variation currently implemented in the model.

Technical Calculations: Length of Stay

After a conviction for a felony offense, a person may be sentenced to prison and receive a designated term within the range for that felony class. For example, an offender sent to prison for a Class 1 offense may receive 5 years, one year above the minimum allowable sentence of 4 years and below the maximum of 15.[5] Most offenders will not serve that entire sentence in prison. The difference between the sentence and the actual length of stay is largely due to credited time for good behavior, credits for time served pre-sentence in jail, and/or credits awarded for participating in programming or removed for

[5] Some offenders may receive extended terms beyond the usual prison term authorized. These extensions are based on a variety of factors specified by statute. 730 ILCS 5/5-5-3.2.

behavior problems. In general, SPAC uses the following equation to describe the length of stay a person will ultimately serve in prison:

Equation 1

$$Length\ of\ Stay_i = \left[\sum \left(Multiplier\_TIS_{ij} \times Sentence_{ij}\right)\right] - JailTime_i + adjustment_i$$

$Length\ of\ Stay_i$ is the actual length of stay for individual i and is only observable at the time of the exit from prison. Additional time served due to a technical violation would be counted as a separate prison admission with its own length of stay.

$Sentence_{ij}$ is the *jth* prison sentence for individual i that is determined in court. Incarcerated persons can serve this entire sentence but often serve much less. For example, murderers and other offenders subject to Illinois' truth-in-sentencing laws must serve 100%, 85%, or 75% of the sentence imposed, depending on the exact offense. (730 ILCS 5/3-6-3(a)(2).) Each offender can have one or more sentences, including consecutive sentences.[6] (730 ILCS 5/5-8-4.) The sentences for a single offender can be mixed, with some having truth in sentencing and others not.

$Multiplier\_TIS_{ij}$ is an adjustment to $Sentence_{ij}$ for individual *i* based on if the *jth* sentence was subject to the truth in sentencing restrictions on good-time sentence credit. Most offenders are not subject to truth-in-sentencing, so IDOC data show eligibility for "Day-for-Day" sentence credits. This means that incarcerated persons may receive day-for-day good-time credit, or a one day reduced stay in prison for each day of good behavior. Full day-for-day credit is frequently earned, so the model will assume $Multiplier\_TIS_{ij} = 0.50$ for all cases of prisoners sentenced under day-for-day truth in sentencing. Depending on the offense, the truth in sentencing multiplier can also take on the values of 0.75, 0.85, or 1.00 to match the credit eligibility, as determined by IDOC. First-degree murderer admissions, for example, receive a multiplier of 1.00 because statute dictates they are ineligible for good-time credit and they must serve 100% of their prison sentences. Exceptions to this rule are discussed below.

$JailTime_i$ is how much time individual i served in jail before admission to IDOC. For some individuals, they may serve their entire prison sentence in a county jail. In these cases, the admission will result in no—or a very short—length of stay in prison.

SPAC calculates a preliminary length of stay (*i.e.*, an early part of the calculation in the projection method, not preliminarily served in prison) by multiplying a truth-in-sentencing (TIS) multiplier by the sentence length and subtracting the time credited for a jail stay prior to sentencing. At individual i*'s* exit, the difference between the true length of stay and the preliminary length of stay is labeled $adjustment_i$. This adjustment term would encompass anything excluded in the formula for the preliminary length of stay that would add or remove days to the actual length of stay—for example, the inmate may lose good-time credits; may take additional programming credits; or may have his or her conviction reversed and be immediately released. Each exit has its own adjustment, which can be zero, negative, or positive.

The challenge is that the true exit date, and hence the actual length of stay, is observed only in the exit data. However, the projection model must base projections on those admitting in the future and those currently in the prison population that have not yet left prison. Therefore, an exit date must be estimated. SPAC has the data required to calculate the preliminary length of stay but not the true adjustment term because the exit has not yet occurred. The procedure SPAC uses to estimate the adjustment term is to estimate it from the exits in the prior three years, conditional on several grouping variables. This method

[6] The '∑' symbol denotes a sum. In Equation 1, the sum is of all consecutive sentences for that individual.

can be modified. For a projection beginning with the prison population as of 6/30/2015, the calculations will use exits from 7/1/2012 through 6/30/2015 to estimate the adjustment term. For most future admissions, the adjustment term associated with their "group" is added or subtracted to the estimated preliminary length of stay. The grouping strategy is discussed below.

Without the adjustment term, the distribution of the length of stay for the exits in any given year is likely biased downwards if applied to the admissions in the future because of a large number of exits with relatively shorter sentences and lengths of stay. Therefore, the adjustment term is estimated to be the average adjustment from the exits grouped with the combination of:

a. offense class,
b. violent vs. non-violent offense,
c. sentence type (regular/concurrent vs. consecutive), and
d. 15-day preliminary length of stay increment.

The adjustment term is only calculated if there are at least 15 exits in each group defined by a, b, c, and d (*i.e.*, an adjustment for all offenders who meet these four criteria: Class 4, non-violent, regular/concurrent, and with an estimated stay of 301 to 315 days). Exits on technical violation admissions are not included in the adjustment estimation, nor are deaths.[7] If there are not at least 15 exits in this group defined by the combination, the adjustment is instead calculated on the same groupings in {a,b,c,d} except using a 30-day preliminary length of stay increment. This process is recursive until an increment with at least 15 exits is found from 15, 30, 60, 180, or 365.25-day increments.[8] If no such increment exits, the adjustment is fixed to a value of zero, meaning that the model uses the sentence length, truth-in-sentencing classification, and jail term in calculating the expected exit date.

Equation 2

$$\widehat{Length\ of\ Stay_i} = \sum \left(Multiplier\_TIS_{ij} \times Sentence_{ij}\right) - JailTime_i + \overline{adjustment}_{abcd}$$

For example, a regularly sentenced admission with a Class 1 violent offense having a preliminary estimated length of stay between 1,426 and 1,440 days would have an adjustment of -109 days.[9] There were 17 exits with those groupings from FY2013-FY2015 and they served on average 109 days less than what was preliminarily estimated. A preliminary estimated length of stay between 1,471 and 1,485 days in those same groupings would require the recursive step, as there were only 8 exits in FY2013-FY2015 that met that criteria. Instead, the adjustment of -136 days is drawn from 22 exits with a preliminary estimated length of stay between 1,471 and 1,500 days.

In equation 2, $Length\ of\ Stay_i$ is an estimate of the length of stay. As described above, the true length of stay will not be observed until the time of the exit. Overall, the adjustment calculation used by SPAC intends to arrive at a more accurate length of stay estimate by including a mean adjustment from actual exits conditional on the group described in {a,b,c,d}. The projected length of stay is then calculated by summing the preliminary length of stay and $\overline{adjustment}_{abcd}$ for each row. Using the projected length of stay, an estimated exit date is then created.

The true length of stay would have an additional adjustment γ, that is only observable upon release and is specific to a particular length of stay on an admission of a particular offender, as in equation 4. This equation shows the true length of stay, which cannot be known in the projection because the last

[7] Deaths are separately estimated as a probability based on life expectancy in the projection.
[8] The 1/4th day is added to the 365-day increment to account for leap years.
[9] Note: the hat symbol ($\widehat{Length\ of\ Stay_i}$) represents an estimation of the true value. The bar symbol ($\overline{adjustment}_{abcd}$) represents an average for the calculated adjustments.

adjustment, γ is left out of our projected length of stay prediction, as shown in equation 3 which represents the true adjustment.

Equation 3

$$adjustment_i = \overline{adjustment}_{abcd} + \gamma$$

Equation 4

$$Length\ of\ Stay_i = \sum\left(Multiplier\_TIS_{ij} \times Sentence_{ij}\right) - JailTime_i + \overline{adjustment}_{abcd} + \gamma$$

In sum, the adjustment term approach described above is intended to reduce, on average, the adjustment term for each individual i closer to zero, approximated by the grouped adjustment term based on historical data. Restated: Equation 4 uses all available historical data to estimate the expected length of stay as close to reality as possible. The approach allows the model to account for known variation that is, prior to release from prison, unknown. Because the known variation represents in part discretionary sentence credit policies, the model can then simulate future changes to these policies to see the population impacts. So long as past discretionary policies and unpredictable releases match the patterns over the past three years, the approach results in an accurate length of stay predictor.

Estimating Length of Stay for Technical Violators

Illinois requires one year of mandatory supervised release (MSR) for Class 3 and 4 offenders, two years for Class 1 and 2 offenders, and three years for murderers and Class X offenders. There are some additional, extended MSR/parole terms for certain offenses. If the individual violates a condition of the release—for example, getting rearrested—the person may be returned to prison as a "Technical Violator."[10] Technical violators may serve up to the remainder of the MSR term in prison, depending on a PRB determination and IDOC's credit policies. The lengths of stay are thus partially due to the offense class, partially due to current policies, and partially related to PRB discretion points. For example, prior research indicates that in periods where there are more technical violation admissions, the length of stay for those admissions decreased.[11]

SPAC uses a simulation approach where the length of stay for technical violators in the initial prison population and future admissions is drawn randomly from a recent cohort of technical violator admission and prison population records, conditional on class. The random selection is from the FY2013 technical violator admissions and prison population data, which are linked to their exits to determine the lengths of stay. The choice of year or years here is important because it reflects the revocation policies, PRB practices, and recidivism patterns. SPAC can adjust the data used for the simulation, but FY2013 is sufficiently recent to give a reasonable estimate but not so recent that a large portion of observations would lack an exit to match for determining the length of stay. If an exit had not yet existed (about 10%), the simulation uses the projected sentence discharge date, which is calculated by IDOC.

The cumulative distribution of length of stay was then constructed for both the admissions and prison population by offense class. An example of this analysis is below. For 2013 technical violator admissions who had been originally admitted on a Class 1 offense, one had a length of stay of 2 days, one

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[10] If the person is rearrested, reconvicted, and the new conviction returns the individual to prison, that case is counted as a new admission to prison. In contrast, if the person does not receive a new conviction but is returned to prison for violating the terms of their release, that case is counted as a technical violation admission and is discussed in this section.

[11] Olson, David, Stemen, Don, Saltmarsh, Kathryn, Karr, Steve, & Sharon Shipinski. Drivers of the Sentenced Population: MSR Violators. Research Briefing, Illinois Sentencing Policy Advisory Council. Summer 2013. Springfield, Illinois.

had a length of stay of 4 days, and three had a length of stay of 9 days. Twelve had a length of 9 days or less (the cumulative number exiting), which is approximately 1% of the Class 1 technical violator admissions (99% had more than 9 days in prison after a technical violation).

Figure 1. Technical Violator Length of Stay Cumulative Distribution View

Source	Fiscal Year	Class	Length of Stay (days)	Number with LOS	Number in Class	Cumulative Number Exiting	Cumulative Distribution	Proportion Remaining
A	2013	1	2	1	1149	1	0.087%	99.913%
A	2013	1	4	1	1149	2	0.174%	99.826%
A	2013	1	5	1	1149	3	0.261%	99.739%
A	2013	1	6	6	1149	9	0.783%	99.217%
A	2013	1	9	3	1149	12	1.044%	98.956%
….	….	….	….	….	….	….	….	….
A	2013	1	716	1	1149	1088	94.691%	5.309%
A	2013	1	717	2	1149	1090	94.865%	5.135%
….	….	….	….	….	….	….	….	….

For each admission row that is used to simulate future admissions, a pseudo-random number is generated on a uniform distribution between 0 and 1.[12] A query then finds the closest cumulative distribution value within the offense class to that random number where the random number is greater than or equal to the cumulative distribution and uses the length of stay in that row as the simulated length of stay. For example, in Figure 1, one admission row with pseudo-random number 0.94721 would use 716 days as the technical violation length of stay. This length of stay is added to their admission date in SQL to create a projected exit date.

The projection model currently uses the FY2013 technical violator admissions and prison population in the construction of the table from which future admissions are randomly drawn. This setting is adjustable, depending on whether assumptions about FY2013 are appropriate as a baseline. In some cases, if this assumption is inappropriate, the results may still be useful as a baseline. Additionally, much like simulation of the sentence length and number of admissions, the length of stay and number of technical violation admissions can be adjusted to test various policy proposals.

Technical Calculations: Number of Future Admissions

Number of Future Admissions

The SPAC projection model assumes that the number of admissions in future years will be equal to the average number of admissions in the past three years. This approach diminishes the effect of using just the single most recent year. However, if admissions have been on a declining trend and continue to do so in the future, this approach would overestimate the number of admissions.

[12] A pseudo-random number is simply a random number generated by a computer. It is technically pseudo random because the creation of the number follows a set pattern and, although it closely resembles random numbers, it can be reproduced.

The current version of the model uses all admissions from fiscal year 2013 to 2015 and randomly selects 1/3 of the admissions.[13] The approach means that the number of admissions in each future year are the average of the past three with regards to sentence lengths (see above sections), type of offenses and felony classes, and demographics. This assumption can be relaxed or modified in future iterations of the model, but the simplistic use of the average of the past three years gives a baseline estimate that is both reasonable and understandable to policymakers and system stakeholders.

Length of Stay in Future Admissions

The future admissions are assumed to have the same sentences as those imposed over the past three years. This assumption coincides with the methodology for determining the number of admissions. This approach also assumes that the sentences imposed, jail time, truth in sentencing, and adjustment terms will apply as in the past. The use of the past three years' sentencing patterns is adjustable and will be adjusted as sentencing changes over time. For the present, the approach is to keep the sentences, offense classes, offense types, and other sentence data consistent with admission records from FY2013 to FY2015.

[13] SPAC first tested a model where each admission was kept but weighted by 1/3. This approach did not significantly change the results but led to much longer processing time.

Calculation of Future Admissions

To simulate future admissions, SPAC joins the real admission information with a calculation table to create a row for each future admission and the expected exit date for that admission.[14] Figure 2 shows a graphic of how this join works. The incremented value is added to the admission year to create a new admission year, creating 30 future admission rows for each admission in the base admission set and essentially duplicating the admissions from FY2013 to FY2015 once for each year in the future defined by the projection model. For example, using three admissions from FY2013 to FY2015, we can duplicate each row 30 times to project admissions 30 years into the future. Figure 3 shows the result of the cross join and the new simulated admission year. Only the first 4 rows for each result of the cross join are shown.

Figure 2. Imputation of admissions simulation – cross join

Admissions rows from FY2013 – FY2015

Admission ID	Admission Month	Admission Date	Admission Year	…Other Fields….	Weight
125	7	18	2014	….	1.0
126	11	10	2014	….	1.0
127	4	8	2015	….	1.0

X

Future admission year end dates	
Fiscal Year End Date	**Increment**
6/30/2016	1
6/30/2017	2
6/30/2018	3
6/30/2019	4
….	
6/30/2045	30

Figure 3. Imputation of admissions simulation – cross join results

Admission ID	Admission Month	Admission Date	Admission Year	…Other Fields….	Weight	Fiscal Year End Date	Increment	(Admission Year + Increment) New Admission Year
125	7	18	~~2014~~	….	1.0	6/30/2016	1	2015
125	7	18	~~2014~~	….	1.0	6/30/2017	2	2016
125	7	18	~~2014~~	….	1.0	6/30/2018	3	2017
125	7	18	~~2014~~	….	1.0	6/30/2019	4	2018
126	11	10	~~2014~~	….	1.0	6/30/2016	1	2015
126	11	10	~~2014~~	….	1.0	6/30/2017	2	2016
126	11	10	~~2014~~	….	1.0	6/30/2018	3	2017
126	11	10	~~2014~~	….	1.0	6/30/2019	4	2018
127	4	8	~~2015~~	….	1.0	6/30/2016	1	2016
127	4	8	~~2015~~	….	1.0	6/30/2017	2	2017
127	4	8	~~2015~~	….	1.0	6/30/2018	3	2018
127	4	8	~~2015~~	….	1.0	6/30/2019	4	2019

[14] In practice, this is a Cartesian product in SQL via a cross join against a table of dates and a value that is incremented relative to the starting prison population date (in this case, the prison population on 6/30/2015).

The Prison Population Date Check

The 'Other Fields' column in figures 2 and 3 includes the projected length of stay (LOS) and projected release date. As discussed above in the length of stay calculations section, each record will combine the observable sentence imposed, truth in sentencing, jail time, and an adjustment term to create a projected release date. The records are then duplicated for each expected future admission (figure 2) and then a second join is applied on the result to compare if that record still exists on a set future date.

The simulation then shows the prison population when each row is kept, keeping all rows where the simulated admission date is less than the desired date (*i.e.*, to check the simulated population on January 1, 2025, the row was admitted before that date) *and* the projected exit date is greater than the desired date (*i.e.*, the row has not yet left prison on that date). The resulting rows are the admissions that are in prison on the given *Future Prison Population Date*, based on our estimated length of stay. Figure 4 shows a graphic of the join and the full result set in figure 5, while the rows that match the two conditions above are given a value of 1 in the last field, "In Prison," and are retained.

Figure 4. Add Future Prison Population Check Date – Inner Join

Simulated future admission rows

Admission ID	Simulated Admission Date	Projected LOS (days)	Projected Exit Date	…Other Fields….	Weight
125	7/18/2015	524	12/23/2016	….	1.0
125	7/18/2016	524	12/24/2017	….	1.0
125	7/18/2017	524	12/24/2018	….	1.0
125	…….	524		….	1.0
125	7/18/2045	524	12/24/2046	….	1.0
126	11/10/2015	1200	02/22/2019	….	1.0
126	11/10/2016	1200	02/22/2020	….	1.0
126	11/10/2017	1200	02/22/2021	….	1.0
126	11/10/2018	1200	02/22/2022	….	1.0
126	…..	1200	…	….	1.0
126	11/10/2045	1200	02/22/2049	….	1.0

X

Future Prison Population Date
6/30/2016
6/30/2017
6/30/2018
6/30/2019
….
6/30/2045

Figure 5. Imputation of admissions simulation – inner join results

Admission ID	Simulated Admission Date	Projected LOS (days)	Projected Exit Date	…Other Fields….	Weight	Future Prison Population Date	In Prison (0/1)	Pseudo-Random Number
125	7/18/2015	524	12/23/2016	….	1.0	6/30/2016	1	0.254347
125	7/18/2015	524	12/23/2016	….	1.0	6/30/2017	0	0.786127
125	7/18/2015	524	12/23/2016	….	1.0	6/30/2019	0	0.112481
125	7/18/2015	524	12/23/2016	….	1.0	….		…..
125	7/18/2015	524	12/23/2016	….	1.0	6/30/2045	0	0.549752
126	11/10/2015	1200	02/22/2019	….	1.0	6/30/2016	1	0.369751
126	11/10/2015	1200	02/22/2019	….	1.0	6/30/2017	1	0.000044
126	11/10/2015	1200	02/22/2019	….	1.0	….		…..
126	11/10/2015	1200	02/22/2019	….	1.0	6/30/2045	0	0.074668

This step also adds a pseudo-random number from a uniform distribution between 0 and 1. This number will be used in the next step to remove rows based on the probability of death (referred to as "The Mortality Check," discussed below). The ultimate decision of whether or not to retain each row through this step will be dependent on the Mortality Check.

The Mortality Check - Accounting for Mortality over Time

The simulation used here requires some estimation of life expectancy to account for natural life sentences, long sentences, and admissions of the elderly. Mortality rates from the U.S. Centers for Disease Control and Prevention's Division of Vital Statistics are available for the general population by age, race/ethnicity, and sex.[15] Recent national research indicates that mortality rates within prison are different from the general population, varying in the direction and magnitude of difference by race and sex.[16] SPAC uses this research to adjust the mortality rates in the mortality check algorithm. Preliminary analyses show that the simulation without such adjustment indicates a fairly large (30-50%) increase of the number of deaths in prison compared to the actual number of deaths. SPAC uses the CDC mortality rates but adjusts to match the recent national research and Illinois data.

SPAC accounts for mortality as follows: For each row that remains in the Prison Population Date Check (Figure 4), a join is performed to an age-race-sex specific mortality table (those with unknown demographics will be joined to the general population mortality values). This table has age-race-sex specific probabilities, which are typically low in most ages but rapidly increase in older ages, with age 100 having a probability of death being 1.0. The random number is compared to the probability of death for that age-race-sex combination and, if the random number is less than the probability of death, the row is removed from the population estimate. This step is a preliminary check and can be seen in Figure 5 (Mortality Check Step_1 column).

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[15] U.S. Center for Disease Control and Prevention (CDC). 2016. Tables 1, 5-12. Retrieved from http://www.cdc.gov/nchs/nvss/mortality_tables.htm.

[16] Noonan, Margaret E. and Scott Ginder. Understanding Mortality in State Prison: Do Male Prisoners Have an Elevated Risk of Death? Justice Research and Policy. June 2015 16: 65-80.

The simulation takes a second step to remove any admission from future years. In other words, once an admission row is assigned to be removed, they are removed from all additional years. The "Mortality Check Final" field in Figure 5 shows such an example. In this case, even though the prior step indicated the admission with ID 127 would remain in prison on 6/30/2018, the preliminary mortality check randomly selected this person to be removed the prior year and, therefore, all later years must be removed.

Figure 5. Mortality Check Simulated Final Results Example

Admission ID	Simulated Admission Date	Age	Projected Exit Date	…Other Fields….	Weight	Future Prison Population Date	In Prison (0/1)	Mortality Check Step_1	Mortality Check Final
125	7/18/2015	34	12/23/2016	….	1.0	6/30/2016	1	0	0
125	7/18/2015	35	12/23/2016	….	1.0	6/30/2017	0	0	0
125	7/18/2015	36	12/23/2016	….	1.0	6/30/2018	0	0	0
125	7/18/2015	37	12/23/2016	….	1.0	6/30/2019	0	0	0
125	7/18/2015	…	12/23/2016	….	1.0	….		…..	
125	7/18/2015	64	12/23/2016	….	1.0	6/30/2045	0	0	0
126	11/10/2015	58	02/22/2019	….	1.0	6/30/2016	1	0	0
126	11/10/2015	59	02/22/2019	….	1.0	6/30/2017	1	1	1
126	11/10/2015	60	02/22/2019	….	1.0	6/30/2018	1	0	1
126	11/10/2015	61	02/22/2019	….	1.0	6/30/2019	1	0	1
126	11/10/2015	….	02/22/2019	….	1.0	….			
126	11/10/2015	88	02/22/2019	….	1.0	6/30/2045	0	1	1

Including the Current Prison Population

The person-level file of inmates held in prison on June 30, 2015 is the starting point for the projection. This number represents all individuals in prison on this date at the beginning of the projection. The length of stay is not calculated any differently for this group compared to admissions in the status quo simulation—SPAC uses the sentence imposed, truth-in-sentencing and sentencing characteristics, jail time, and the adjustment term to estimate a projected release date. Each prison population row is assigned a weight of 1.0. After estimating the length of stay as described above, the prison population is checked for exiting and mortality just as described for the admissions calculations.

Final Step – Summation of Weights

After performing the Prison Population Date Check and the Mortality Check, the weights in the retained rows can be summed by the future prison population dates to obtain the prison population in the future. The future population will solely be the result of estimated future admissions, the expected lengths of stay, and the calculations with those inputs described above.

The key advantage for this model is that the weight can be modified before summation based on proposed policy and/or changes to assumptions. For example, if a policy would propose to no longer allow sentences to prison for drug possession, the weight for these admissions can simply be changed to zero or reduced, if the model assumes that some offenders entering for a drug possession will no longer be sent to prison. If they would instead enter on some other offense, the weights of those other offenses could be increased to account for expected increases in future admissions. If a lapse of time is expected before a policy is fully implemented, the weight can be adjusted using the increment field with conditional logic in the SQL. The flexibility of the weight field allows SPAC to account for changes to admissions over time, depending on the type of policy proposal and the "what if" scenario SPAC needs to model.

In addition to summation of the weights, SPAC can export the rows of data for a selected future date to create simulated admissions, population, and exits files. These files would look like the past data extracts provided by IDOC and allow for examination of potential problems in the simulation. The approach allows SPAC to export, for example, a simulated extract file similar to our current prison population files. As opposed to a complex formula for a projection, this approach is, for the most part, a count of individuals in prison on a certain date based on admissions and expected lengths of stay.

Conclusion

This model will continue to evolve as more data becomes available and the underlying assumptions are refined and improved. With the finalization of this model, population projections will be included in future fiscal impact analyses and annual prison population projections will be published as mandated in SPAC's authorizing legislation. While 100% accuracy will be forever elusive, SPAC is confident that the results produced with this methodology will prove to be useful as Illinois continues to examine sentencing policy and use data-driven evidence to reform the criminal justice system.