

The Cook County Assessor's Property Tax Rate Simulator

Technical Documentation, V.1.0

Cook County Assessor's Office, Data Science Department

Published December 12, 2019

Introduction

Property taxes are unlike many other taxes, and both the public and even real estate professionals struggle to understand how they work. This tool is designed to accomplish two goals. First, by demonstrating how property taxes are calculated in the City of Chicago in Cook County, we hope to help people understand why their bills have changed in the past. Second, we hope to enable people to be able to form some predictions about what may happen to property tax bills under various scenarios.

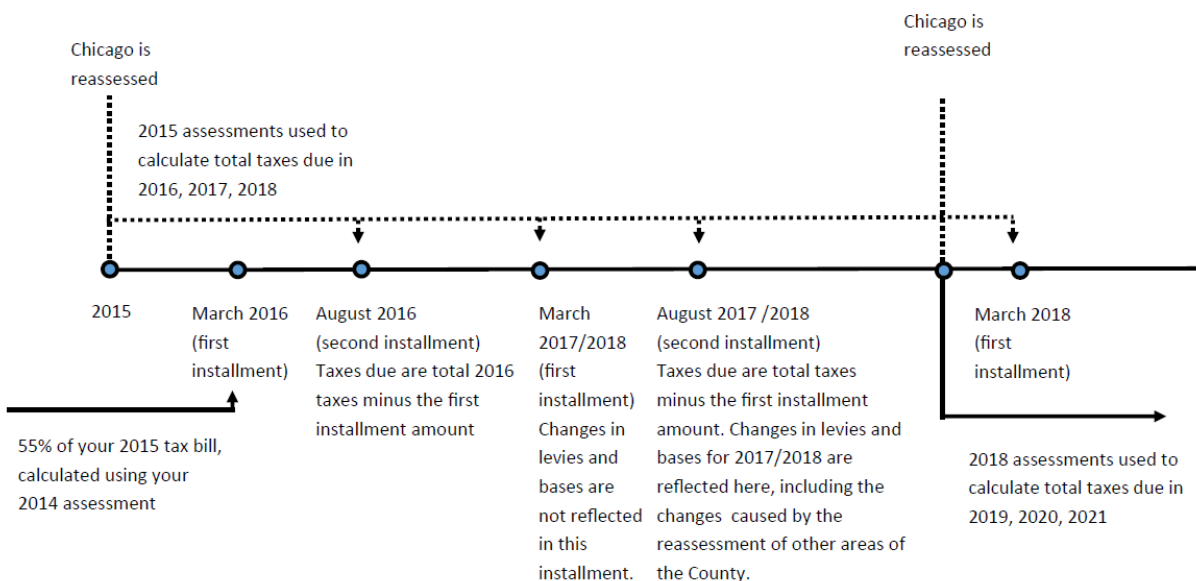
Property taxes can be a source of risk in a real estate transaction, so future homeowners and analysts may need to estimate future tax liabilities. Even for someone familiar with Cook County and the City of Chicago, this can be challenging. For an analyst based in a different state or country, it is nearly impossible. We hope to reduce some of the uncertainty around property taxes, and therefore allow some quantification of that risk.

Please feel free to provide feedback by emailing ratesim@cookcountyassessor.com

First and Second Installment Bills in Cook County

The timing and amount of property tax payments in Cook County can be very confusing, and changes in liability from payment to payment can be difficult to anticipate. This is in part because of the way they are calculated. Annual property tax bills are paid one year in arrears: the taxes paid in 2019 are calculated on property assessments, exemptions, incentives, and municipal tax levies from 2018. Furthermore, the full year's tax bill is split into two installments that are calculated and mailed separately. The sum of these first and second installments equals the full taxes for that tax year.

Simplified Assessment and Tax Bill Timeline



First installment tax bills, typically billed in February, are equal to 55% of the prior year's total tax bill. As such, the first installment is fully predictable. The first installment tax bill sent to a property in 2020 equals 55% of the total tax amount billed in 2019 for tax year 2018.

Second installment bills, typically billed in July, are the difference between the first installment payment and the total tax bill for that year. This tax bill is not predictable using the previous tax bill because tax rates have not been calculated yet.

Every property in the County is re-assessed every three years on a rolling basis. The City of Chicago is reassessed every three years from 2015 (2015, 2018, 2021, etc.). A re-assessment will impact second installment tax bills in the calendar year following the re-assessment. The graphic below illustrates how interaction between the timing and nature of first and second installment tax bills, combined with the re-assessment cycle, can make tax liabilities difficult to anticipate.

While this simulator does not explicitly deal with these timing issues, anticipating cash flow requires awareness of how each bill is calculated. For the remainder of this document, we will refer to each year's total tax bill.

Tax bill Simulation

How tax bills are typically shown

On the second installment tax bills received by taxpayers, there is a "tax calculator" panel on the lower left hand side of the front page. We have reproduced an example on the following page. We will use this as a starting point, to see how our calculation method can be derived from the 'official' method. Throughout this document, and in the simulator, we calculate tax amounts assuming no exemptions or tax incentives.

How we simulate tax bill amounts

There are many ways to 'calculate' a tax bill, arriving at the same final tax amount. In order to clarify a very complicated system, we have calculated tax bills in a slightly different way than are typically shown on tax bills. It uses what we believe to be the simplest and most intuitive method to show the calculation of tax bills.

Verifying the simulator works

Presumably, the user would like to be convinced that this version of a tax simulator works. The easiest way to do this is to follow these steps:

- Use your own property's PIN, or find an arbitrary one:
 - Open [Cook Viewer](#).
 - Find an arbitrary 200, 300, or 500 class PIN in the City of Chicago (or your own)
 - 200: single-family home
 - 300: commercial apartments larger than seven units
 - 500: commercial/industrial property
- [Get a copy](#) of that PIN's second installment tax bill from the Cook County Treasurer's Office.
- Input the correct Class and Property Value from the bill into the simulator.
- Observe that calculated bill is within a rounding error of the actual bill.
- Repeat until convinced.

TAX CALCULATOR					
V_i	←	2017 Assessed Value	48,361	2018 Total Tax Before Exemptions	11,757.04
		2018 Property Value	592,920	Homeowner's Exemption	-681.20
L_i	←	2018 Assessment Level	X 10%	Senior Citizen Exemption	.00
		2018 Assessed Value	59,292	Senior Freeze Exemption	.00
F	←	2018 State Equalizer	X 2.9109		
		2018 Equalized Assessed Value (EAV)	172,593	2018 Total Tax After Exemptions	11,075.84
R_G	←	2018 Local Tax Rate	X 6.812%	First Installment	5,346.75
T_i	←	2018 Total Tax Before Exemptions	11,757.04	Second Installment +	5,729.09
				Total 2018 Tax (Payable in 2019)	11,075.84

For clarity, parameterize these elements and express taxes of property i (T_i) as a function of the parameters of property i and governments G :

$$T_i = V_i L_i F R_G$$

The Equalization Factor is a multiplier applied to all the properties in the County.

How we calculated tax bills

We will show the series of steps we used to re-write the formula above to simplify it.

Let the assessed value be expressed as

$$AV_i = V_i L_i$$

$$T_i = AV_i F R_G \tag{1}$$

Rate calculations

The tax rate of a jurisdiction equals the tax base available for taxation divided by the jurisdiction's extension. To see this, consider the [2018 agency rate report](#) for Chicago Park District. Part of this report is reproduced on the next page. The total Equalized Assessed Value available to this jurisdiction for taxation is \$86,326,178,932. This jurisdiction is trying to raise \$284,530,079 on this base. The ratio of these two numbers is 0.00329598833772229. Due to the technology on which these numbers are divided, this ratio is rounded to 0.0033.¹ Multiplying by 100 returns the jurisdiction's tax rate of 0.330.²

¹ This is the source of the small differences between the calculations in our workbook and actual tax bills.

² Property taxes are expressed as 'mill rates', the rate applied per \$1,000 of assessed value.

Simplified way to read an agency rate report

DATE 06/20/19		TAX YEAR 2018		AGENCY TAX RATE REPORT						
				PRIOR YEAR COOK COUNTY EAV	76,765,302,536	COOK COUNTY 2018 EAV	86,326,178,932			
AGENCY 05-0200-000 CHICAGO PARK DISTRICT				CURR NEW PROP, ANNEX., REC. TIF VAL,		DUPAGE	9,703,001			
PROPERTY TAX EXTENSION LIMITING LAW (PTELL) LIMITING RATE CALCULATION				EXP. INCENTIVES MINUS DISCONNECT PROP	957,951,543	LAKE				
				TOTAL	77,723,254,079	WILL				
2017 AGGREGATE EXTENSION X 1.0210				2018 EAV MINUS NEW PROP, ANNEX., REC TIF VAL, EXP. INCENTIVES PLUS DISCONNECTIONS		KANE				
223,021,588	/	85,377,930,390	=	LIMITING RATE	0.262	MCHENRY				
				AGENCY OVERALL EAV	86,335,881,933	DEKALB				
				TOTAL	86,335,881,933	GRUNDY				
FUND DESCRIPTION OF FUND	LEVY AMOUNT	LOSS AMOUNT	%	TOTAL LEVY	TAX RATE	MAXIMUM ALLOWABLE LEVY	PRELIMINARY TAX RATE	PTELL REDUCED LEVY NO REDUCTION	99.99% OF BURDEN IN COOK COUNTY	FINAL TAX RATE
001 CORPORATE	172,379,203	0		172,379,203	0.6600	172,379,203	0.199661		172,361,965	0.199664
003 BONDS & INTEREST	46,191,222	1,759,808		47,951,030	0.0000	47,951,030	0.055540		47,946,235	0.055541
019 LIABILITY INSURANCE	10,427,696	0		10,427,696	0.0000	10,427,696	0.012078		10,426,653	0.012078
041 AQUARIUM & MUSEUM	27,664,491	0		27,664,491	0.1500	27,664,491	0.032043		27,661,725	0.032043
122 MUN. EMP. A & B	0	0		0	0.0000	0	0.000000		0	0.000000
124 PARK EMP. A & B	13,194,114	0		13,194,114	0.0000	13,194,114	0.015282		13,192,795	0.015282
125 LABOR RET. A & B	0	0		0	0.0000	0	0.000000		0	0.000000
150 RENTAL BLDG COMM 1	0	0		0	0.0000	0	0.000000		0	0.000000
170 PUBLIC BUILDING COMM	0	0		0	0.0000	0	0.000000		0	0.000000
178 CORP. NOTES	0	0		0	0.6600	0	0.000000		0	0.000000
202 HANDICAPPED FUND	12,942,000	0		12,942,000	0.0400	12,942,000	0.014990		12,940,706	0.014990
217 OPERATION & MAINTENANCE PUB. BLDG. COM	0	0		0	0.0000	0	0.000000		0	0.000000
401 PUBLIC BUILDING COMMISSION	0	0		0	0.0000	0	0.000000		0	0.000000
TOTAL CAP FUNDS				223,665,504		223,665,504	0.259		223,643,138	0.259
TOTAL NON CAP FUNDS				60,893,030		60,893,030	0.070530		60,886,941	0.070531
AGENCY GRAND TOTAL				284,558,534		284,558,534	0.330		284,530,079	0.330
2018 NON CAP FUNDS TAX EXTENSION TOTAL				60,886,717.26	2018 TAX EXTENSION GRAND TOTAL		284,876,390.48			

EAV available for taxation

AV_g

Jurisdiction's tax rate

r_g

Tax \$ raised from property taxes

E_g

Again, parameterizing these values, we can express a single agency g's rate as

$$r_g = \frac{E_g}{AV_g F}$$

The cumulative tax rate, R_g , applied to a property is just the sum of each individual jurisdiction's tax rate:

$$R_g = \sum_G r_g = \sum_G \frac{E_g}{AV_g F} = \frac{1}{F} \sum_G \frac{E_g}{AV_g}$$

Substituting this into (1) yields

$$\begin{aligned} T_i &= AV_i F R_g = AV_i F \frac{1}{F} \sum_G \frac{E_g}{AV_g} = AV_i \left(F \frac{1}{F} \right) \sum_G \frac{E_g}{AV_g} = AV_i (1) \sum_G \frac{E_g}{AV_g} \\ T_i &= AV_i \sum_G \frac{E_g}{AV_g} \end{aligned} \tag{2}$$

Notice that the equalization factor divides out of the equation. The formula in cell N14 on the "Simulating Bills" Worksheet in our simulator is

$$G\$21 * VLOOKUP(\$F\$16, Assessmentlevels, 2, FALSE) * \$J9/\$L9/1000$$

Which is the taxes due the Chicago Park District in 2018:

$$T_{i,g} = V_i L_i \frac{E_g}{AV_g} / 1,000$$

Decomposing changes in taxes

What do taxes change over time? From (2), we can see that there are three potential reasons that individual taxes, T_i , can change over time: changes in extensions, E_g , tax bases, AV_g , and individual assessments, AV_i . We can express

$$\begin{aligned} T_i^y - T_i^{y-1} &= \sum_G AV_i^y \frac{E_g^y}{AV_g^y} - \sum_G AV_i^{y-1} \frac{E_g^{y-1}}{AV_g^{y-1}} \\ &= \sum_G E_g^y \frac{AV_i^y}{AV_g^y} - \sum_G E_g^{y-1} \frac{AV_i^{y-1}}{AV_g^{y-1}} \\ \rightarrow \log(T_i^y) - \log(T_i^{y-1}) &= \log\left(\sum_G E_g^y \frac{AV_i^y}{AV_g^y}\right) - \log\left(\sum_G E_g^{y-1} \frac{AV_i^{y-1}}{AV_g^{y-1}}\right) \end{aligned}$$

$$= \sum_G \log(E_g^y) - \sum_G \log(E_g^{y-1}) + \sum_G \log\left(\frac{AV_i^y}{AV_g^y}\right) - \sum_G \log\left(\frac{AV_i^{y-1}}{AV_g^{y-1}}\right)$$

The interpretation of this equation is convenient. The first two terms show the impact of changes in government revenues from the property tax. The second two terms show the impact of changes in assessments.

In our property tax simulator, we approximate this decomposition on “Tax Bill Worksheet” in W20:

$$\begin{aligned} \text{effect of assessments} &= \sum_G AV_i^y \frac{E_g^{y-1}}{AV_g^y} - \sum_G AV_i^{y-1} \frac{E_g^{y-1}}{AV_g^{y-1}} \\ &= (\text{new tax share} - \text{old tax share}) * \text{old extension}^3 \end{aligned}$$

Due to the fact this is an approximation, there is a remainder. This is equally divided between the two effects.

Scenarios

Suppose you wanted to test some counterfactual scenarios. We have built two scenarios into the “Scenario Worksheet.”

Scenario 1: Large increase in the City levy

In Scenario 1, we show what would have happened if the City of Chicago’s 2018 tax extension had been \$100 million larger than it actually was. This is achieved simply by adding 700,000,000 to the actual 2018 base:

$$T_{i,g} = V_i L_i \frac{E_g + 100,000,000}{AV_g} / 1,000$$

We assume the *ceteris paribus* condition – that *only* the City extension changes, and nothing else does. In reality, there may be coincidental economic impacts from an increase in the City extension. But we do not have the capacity to model these.

Scenario 2: Large increase in the City base

Scenario 2 is the most complicated part of the Rate Simulator tool because the tax base is very large and complicated. Code to calculate the actual tax base for the city [can be found here](#). There are three steps to simulating the tax base of the city of Chicago:

1. Sum final assessed value by group: tax year, tax code, township, and major property class.
2. Subtract the sum of exemptions within each group.
3. Subtract the TIF increment from each group.
4. Sum the remaining value by year to get the tax base in each year.

Step 3 is the tricky part. Each tax code in a TIF has a frozen amount. If the total EAV in that tax code increases beyond the frozen amount, the portion of the increase in excess of the frozen

³ Nathan Anderson and Rob Ross. *The Illinois Report*. “[Chapter 3: Rethinking Property Taxation](#).” *The Institute of Government and Public Affairs at the University of Illinois at Chicago*. 2013.

amount *is not available to the taxing jurisdictions as tax base*. So, in order to simulate an increase in the value of a particular group of properties, we have to account for the impact of TIFs on the pass-through of value from the fair market values to the tax base for the City of Chicago. The SQL query that generates the data on the “TIF” worksheet is stored in the [CCAO’s Data Architecture Repository](#).

Scenario 3: TIF Increment Added to the City Base

This is a natural, simpler extension of scenario 2.