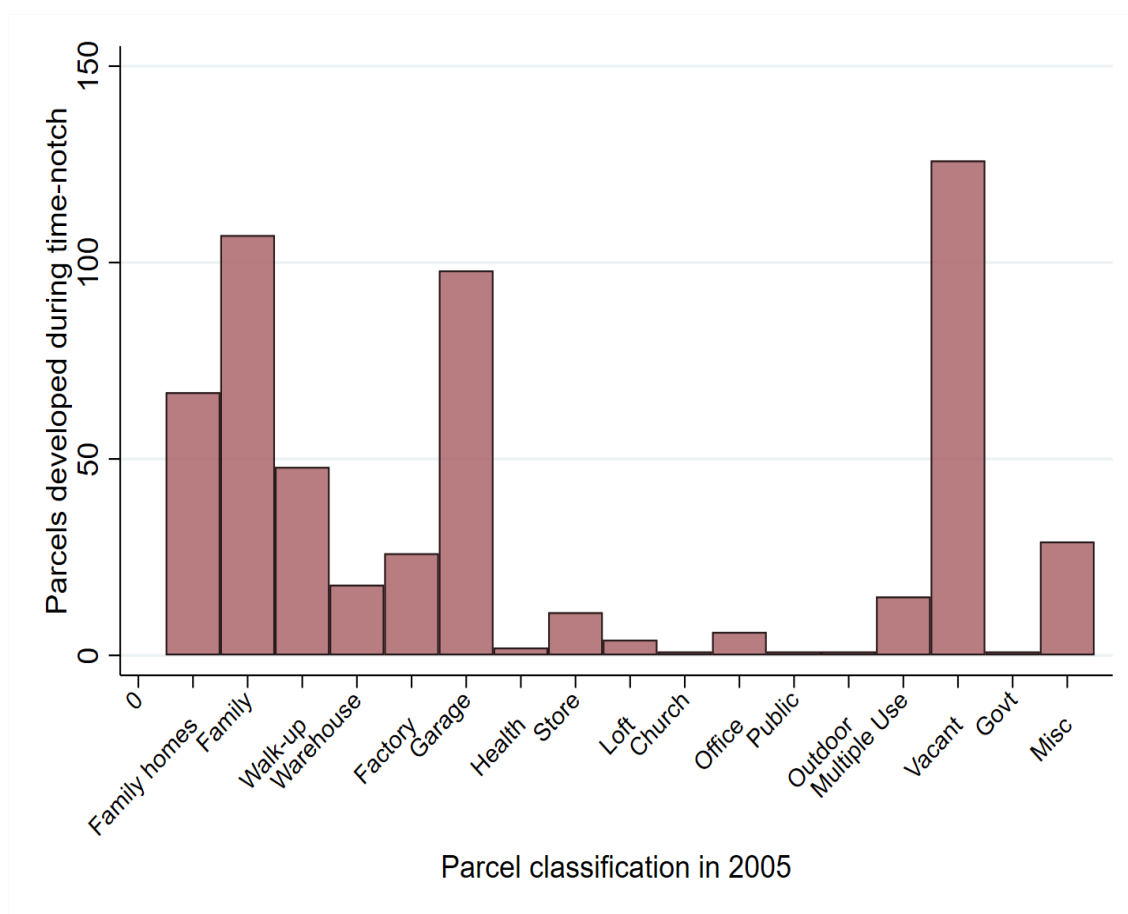


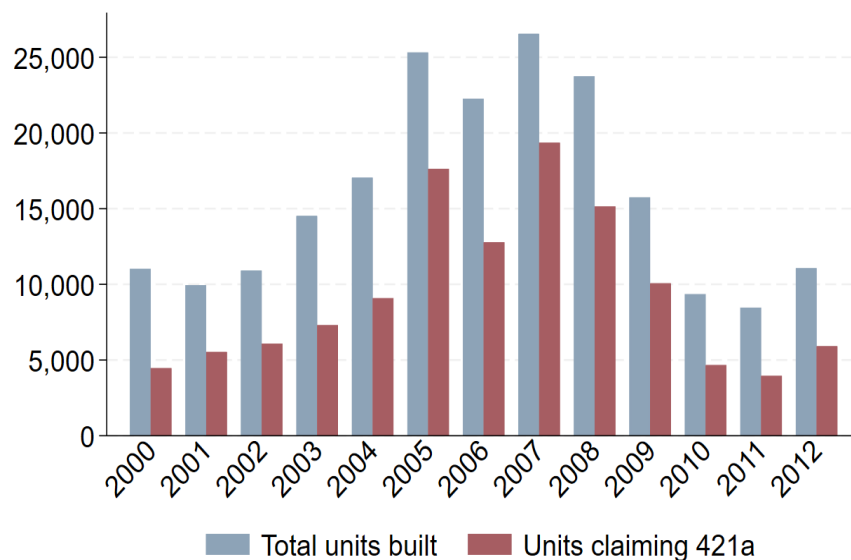
Online Appendix

A-1 Supportive tables and figures

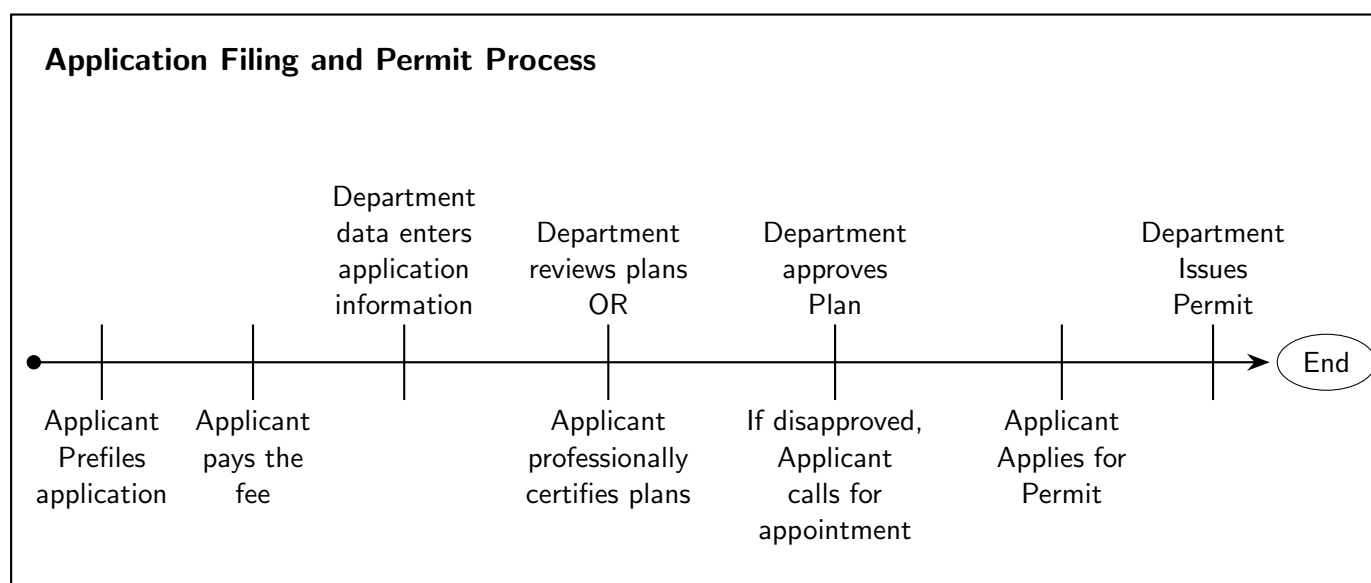
Figure A-1.1: Classification of parcels developed in the time notch



Notes: This figure shows the distribution of the types of parcels that were developed in the time-notch, that is, during 2006-08 and obtained 421a property tax exemption. Data: Primary Land Use Tax Lot Output, 2002-16 and Department of Finance 421a Exemption list 2015.

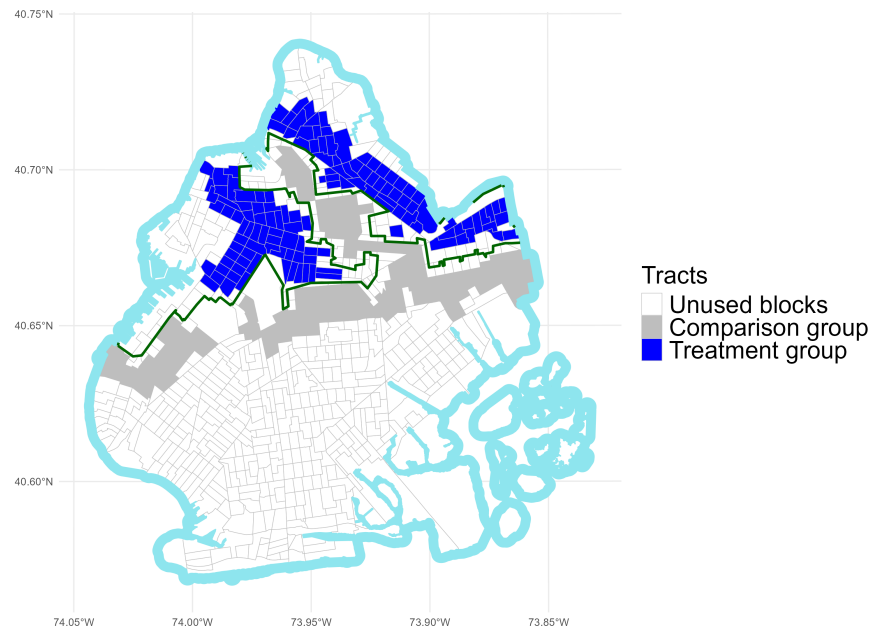
Figure A-1.2: 421a property tax exemption use over time

Notes: Sample restricted to Class 2 residential buildings (defined 3 units and above)— only those that are eligible for the 421a property tax exemption.

Figure A-1.3: Steps required to obtain work permit in New York City

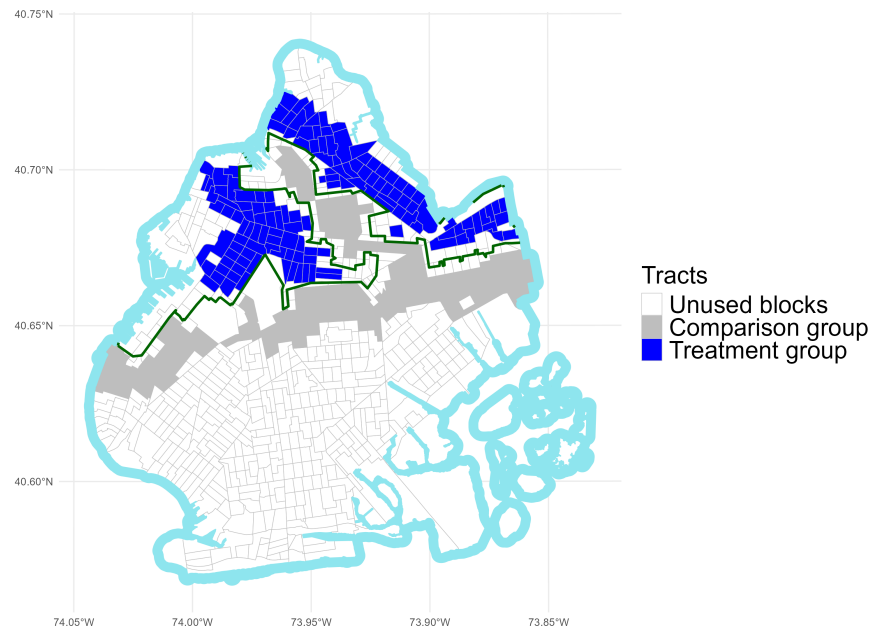
Notes: This figure outlines the key steps in obtaining a work permit in New York City. Source: Department of Buildings

Figure A-1.4: Exclusion and non-exclusion regions in Brooklyn. Treatment and comparison tracts located 1000 meters away from the boundary.



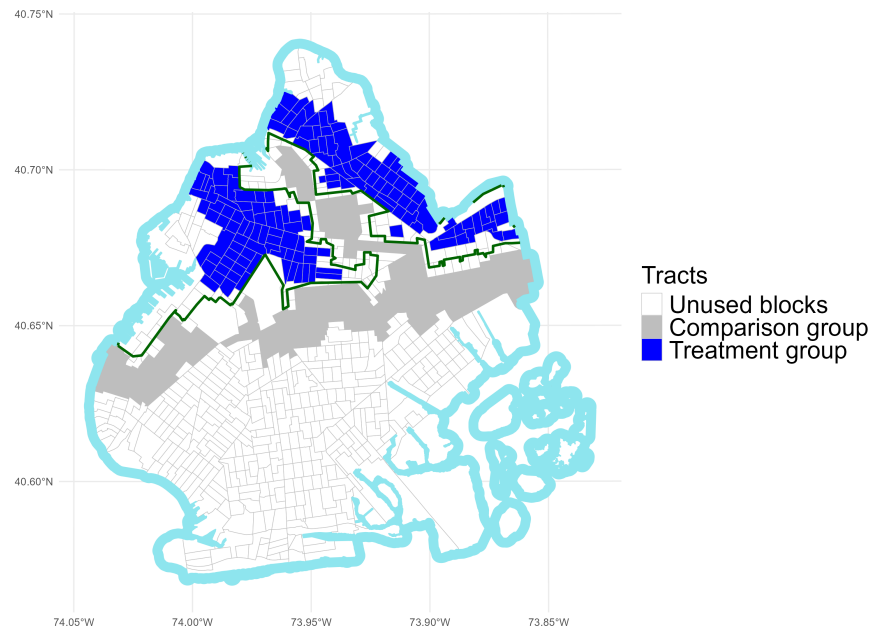
Notes: The green line — indicates the boundary between exclusion and non-exclusion regions for the borough of Brooklyn.

Figure A-1.5: Exclusion and non-exclusion regions in Brooklyn. Treatment and comparison tracts located 1100 meters away from the boundary.



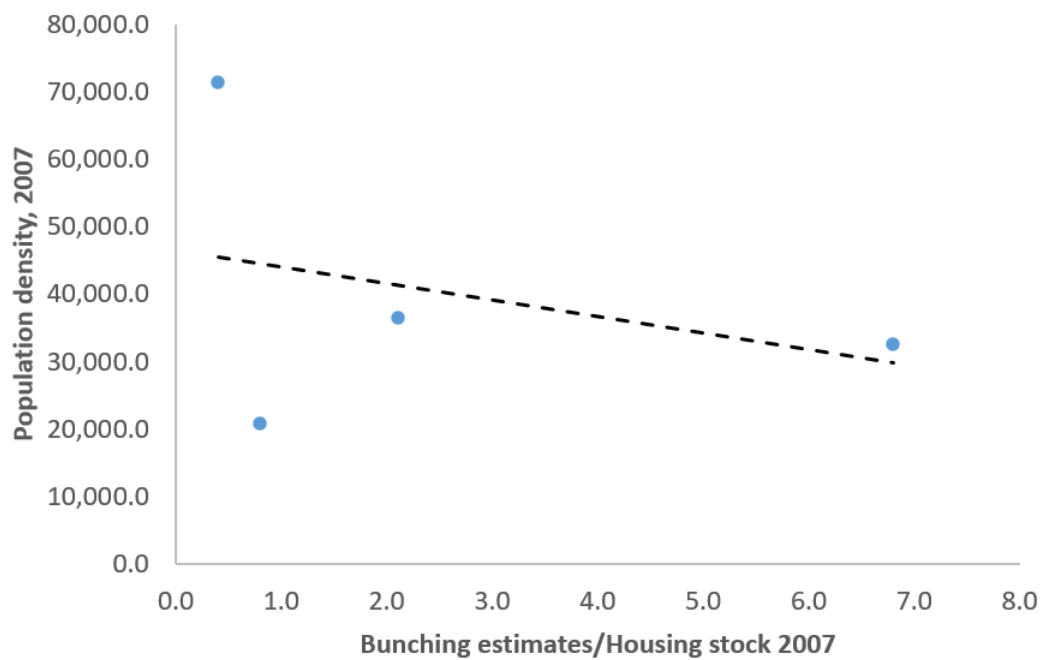
Notes: The green line — indicates the boundary between exclusion and non-exclusion regions for the borough of Brooklyn.

Figure A-1.6: Exclusion and non-exclusion regions in Brooklyn. Treatment and comparison tracts located 1300 meters away from the boundary.



Notes: The green line — indicates the boundary between exclusion and non-exclusion regions for the borough of Brooklyn.

Figure A-1.7: Bunching of tax-exempt housing starts vs. population density by borough



Notes: We obtained 2007 population density estimates from New York Metropolitan Transportation Council (2009). The bunching estimates are in absolute numbers, as reported in row B_{total} in Table 7.

Table A-1.1: Descriptives: Rental parcels in New York City in 2007

	Mean	SD	Min	p25	p50	p75	Max	N
<i>Non-exclusion region</i>								
Assessed value land	436195.25	1441824.5	2373.3333	74000	149000	375000	80300000	13134
Residential area	60771.53	176127.41	1173.9131	17400	34330.17	63237	13498063	13134
Residential units	63.69	154.8	11	21	39	65	10914	13134
Lot area	26586.48	103171.12	1208	5300	10000	18000	5048550	13134
No. Buildings	1.82	5.39	1	1	1	1	109	13134
Market value per sqft	57.09	33.23	.56	36.94	48.55	68.11	689.83	13134
Imputed Rent	686.05	392.77	5.75	459.63	594.34	805.13	8604.19	13134
Rental stock	836575	0	836575	836575	836575	836575	836575	13134
<i>Exclusion region</i>								
Assessed value land	1307870.5	4871917	2562.2222	129000	351000	866000	3.148e+08	16643
Residential area	46875.48	132196.81	100	9860	17281.77	42000	8897465	16643
Residential units	49.860	137.36	11	16	23	43	8756	16643
Lot area	11104.04	54368.63	825	2564	4800	9372	4444613	16643
No. Buildings	1.23	1.28	1	1	1	1	54	16643
Market value per sqft	129.94	137.84	.57	61.86	107.74	178.58	14094.16	16643
Imputed Rent	1462.98	1514.71	3.185	644.05	1037.23	1703.94	31936.91	16643
Rental stock	829826	0	829826	829826	829826	829826	829826	16643

Notes: Summary statistics of rental buildings in 2007. Rental buildings include parcels classified as type C, D or S and having at least 10 units. *Imputed Rent* is obtained by dividing annual full market value by 12 times the number of residential units in the parcel times the average capitalization rate during this period- which is 6%. *Imputed Rent* and *Market Value* are expressed in 2015 US dollars using urban CPI tables provided by BLS. *Rental stock* denotes total rental units stock in buildings with at least ten units. Data: Primary Land Use Tax Lot Output, New York City, 2001-15.

Table A-1.2: Descriptives: Rental parcels in Brooklyn in 2007

	Mean	SD	Min	p25	p50	p75	max	N
<i>Non-exclusion region</i>								
Assessed value land	415871.81	1141634.1	4400	78000	184000	395000	22600000	4487
Residential area	55626.24	109740.99	1173.91	16640	31480	60000	1788439.3	4487
Residential units	57.77	104.59	11	19	36	60	1760	4487
Lot area	21296.154	67464.586	1500	5300	10000	15717	1410820	4487
No. Buildings	1.40	2.55	1	1	1	1	78	4487
Market value per sqft	54.92	29.20	6.22	37.73	46.474	63.997	689.83	4487
Imputed rent	681.81	389.84	11.57	480.36	595.28	773.97	8604.19	4487
H_S	259246	0	259246	259246	259246	259246	259246	4487
<i>Exclusion region</i>								
Assessed value land	261069.5	784087.79	3951.1111	48250	80000	195500	14400000	2444
Residential area	40003.16	91482.79	1008.33	11751	18521	35190	1466751	2444
Residential units	43.5	98.56	11	16	22	38	1836	2444
Lot area	14339.81	47532.54	1296	4000	5750	10200	1079791	2444
No. Buildings	1.34	1.99	1	1	1	1	54	2444
Market value per sqft	78.71	52.66	2.34	44.640656	65.1	97.62	550.8	2444
Imputed rent	893.31	707.75	24.36	499.58	725.05	1078.9497	16172.89	2444
H_S	106311	0	106311	106311	106311	106311	106311	2444

Notes: Summary statistics of rental parcels in 2007. Sample restricted to parcels in Brooklyn. Rental parcels include parcels classified as type C, D or S and having at least 10 units. *Imputed Rent* is obtained by dividing annual full market value by 12 times the number of residential units in the parcel times the average capitalization rate during this period- which is 6%. *Imputed Rent* and *Market Value* are expressed in 2015 US dollars using urban CPI tables provided by BLS. *Rental stock* denotes the total rental units stock situated in buildings with at least ten units. Data: Primary Land Use Tax Lot Output, New York City, 2002-16.

Table A-1.3: Summary statistics for non-notch and notch properties in 2015

	Mean	Median	SD	N	T-test
Building area	13152.702	4146	48192.697	4644	
	21344.83	5118	64792.689	745	-3.3073834
Res units	12.128984	3	45.001232	4644	
	20.296644	4	63.895911	745	-3.3579692
Lot area	3912.1051	2437	6996.7107	4644	
	4806.9987	2500	7289.0423	745	-3.1278333
No. Buildings	1.1302756	1	.65041666	4644	
	1.0939597	1	.33081607	745	2.3540461
Imputed Rent	1819.5576	1477.0795	1485.3728	556	
	2322.8212	2032.8167	1751.3924	152	-3.2385606
If High-income region	.2459087	0	.43067105	4644	
	.35436242	0	.478641	745	-5.8183106
Age	11.300195	11	4.1481946	4607	
	7.0175676	7	1.3459565	740	54.46332
Exclusion region	.22200689	0	.41564051	4644	
	.38389262	0	.486659	745	-8.5907678
If Manhattan/Brooklyn	.32988803	0	.47022285	4644	
	.52751678	1	.49957765	745	-10.103428

Notes: This table summarizes key differences in parcels that started outside the time-notch (first row) and those that started during the time-notch (second row) as of 2015. Sample restricted to parcels that contain non-condo buildings and that were built after 1990. *Building area* refers to the gross square feet residential area developed on the parcel. *High income* is a dummy that takes value one if the parcel is located in above median income census tract. *Imputed Rent* is inferred using Department of Finance's market valuation. *Exclusion region* is a dummy indicating if the parcel is located in exclusion regions which experienced tax increase as part of the tax reform. Data: Primary Land Use Tax Lot Output, 2015 and Department of Finance 421a exemption list 2015.

A-2 Data

Note. This Appendix section is based on [Singh and Baldomero-Quintana \(2026\)](#)

Tax-PLUTO Data. PLUTO and MapPLUTO contain land records of every piece of New York City. Each unit in the records are referred to as a *tax-lot*. An average tax plot consists of 1.26 buildings. PLUTO (which stands for “Property Land Use Tax [Lot] Output”) lists properties at borough-block-tax lot level. It provides information of the property such as address, number of residential and total units, residential and commercial square footage, year built, lot and building area, owner name and number of floors. MapPLUTO provides shapefiles containing precise geographic location of properties on the map.

Under NYC real property law, condos are assessed separately from the traditional tax lot (or a parcel) and are represented by a *condominium tax-lot* that is different from a *traditional* tax-lot. A traditional parcel may contain several buildings, each comprising of several condos. PLUTO data lists information at the *tax-lot* level and not *condominium unit* level. Each parcel in NYC is uniquely identified by its borough-block-tax lot (BBL). BBL consists of three numbers: the borough, which is one digit (coded alphabetically 1-5); the block number, which is up to five digits; and the lot number, which is up to four digits. Each condo, on the other hand is identified by borough-block-condo tax lot (referred to as *condominium* BBL). To identify all condos that share the same parcel, PLUTO data can be merged with another dataset called Property Address Directory (PAD) which contains the directory of condos and their billing BBLs. The PLUTO and Map-PLUTO data was accessed from NYC’s website in March 2018 and provides data updated as of October 2016. Unfortunately, the 2018 version of PLUTO did not publish the data for the calendar year 2007. See <https://www1.nyc.gov/site/planning/data-maps/open-data/dwn-pluto-mappluto.page> for more details.

Geographic Exclusion Boundaries. The map of exclusion regions comes from NYC’s website. Using QGIS we created a shapefile which we merged with PLUTO data to identify whether a parcel (identified by its BBL) is located in *exclusion* or *non-exclusion* regions. The original map can be found at the following address https://www1.nyc.gov/assets/hpd/downloads/pdf/GEA_Map.pdf

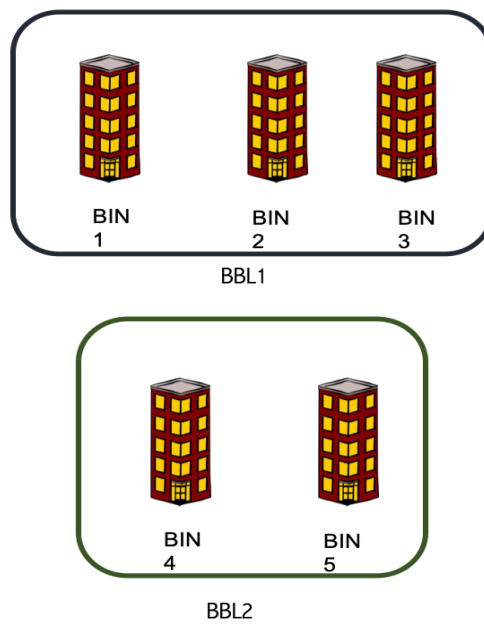
Property Address Directory (PAD). While PLUTO contains rich information at the *billing-lot* or building level and not at *tax-lot* level. While *tax-lot* and *billing-lot* are essentially same for all rental properties and coops, they differ for condos which are individually owned and assessed separately from the building. To identify condos within a building, we use PAD (Property Address Directory) which contains a crosswalk between *billing* BBLs and *tax* BBLs. This directory also provides a corresponding BIN (Building Identification Number) for each BBL which is useful in merging permits data with PLUTO and 421a dataset. The 2018 version of this dataset was downloaded from the following website in May 2018. See <https://www1.nyc.gov/site/planning/>

[data-maps/open-data.page](#) for more details.

Investment or Permits Dataset. NYC Department of Buildings The permit issuance data provides information on permits issued at the parcel-month level. This dataset contains universe of permits issued for any parcel in New York City from 2003 to 2014. A single permit is associated with one building. A parcel undergoing any major alteration or construction must first obtain a permit from the Department of Buildings.

There are three types of permits: (i) *demolition* (permit type denoted as ‘DM’), (ii) *new building* construction (permit type denoted as ‘NB’), (iii) and *major alteration* that changes occupancy structure of the building (permit type denoted as A1). We restrict my analysis to DM, NB and A1 type permits only. Also, we focus on *initial* issuance of permits and we do not consider *renewal* permits in our analysis. See <https://data.cityofnewyork.us/Housing-Development/Historical-DOB-Permit-Issuance/bty7-2jhb/data> for more details.

Properties with 421a Exemption or 421a dataset. The website of the NYC Department of Finance contains a report on all properties receiving the 421a partial tax exemption listed by borough, block, tax-lot, neighborhood, building class, tax class and address. This dataset lists all condos and buildings that received the 421a Tax Exemption in fiscal year 2015-16. The combination of borough, block and tax-lot forms the unique property identifier (*tax-BBL*) which we use to merge this dataset with others. See <https://www1.nyc.gov/site/finance/benefits/benefits-421a.page> for more details. Figure A-2.8 shows how identifiers for buildings (BIN) and parcels (BBL) from different datasets – PLUTO, permits, and the list of buildings that have a 421a exemption – are merged for our analysis.

Figure A-2.8: Geographies in New York City Datasets

Notes: We show relevant identifiers for parcels and buildings. BBL denotes a parcel (billing-tax-lot) which may contain one or more buildings. Each building is associated with a unique identification number called BIN. Investment (permits) data is at the building level since a single permit is associated with one building only (buildings are identified by unique BIN), whereas rents/market valuation dataset is at the parcel level (BBL). Further, sales dataset is either at the apartment (identified by the 'tax' BBL) or building level (identified by 'billing' BBL). A parcel contains approximately a building. The unit of analysis in the paper is a parcel (identified by a billing BBL).

A-3 Estimation of the property taxes in New York City

Note: This entire Appendix section is almost identical to the Appendix A-6 in [Singh and Baldomero-Quintana \(2026\)](#).

The property tax is determined according to the following formula:

$$\text{Annual tax} = \text{tax rate} \times \underbrace{[\text{assessment rate} \times \text{Annual Market Value} - \text{Exemption}]}_{\text{Assessed Value}} - \text{Abatement} \quad (6)$$

Several components determine a landlord or homeowner's annual property tax bill. First, the assessment rate determines the fraction of market valuation subject to property tax. For instance, this ratio is 6% for owned one-family homes and 45% for rental buildings.¹¹ Second, exemptions reduce the assessed value. Some of the available exemptions include STAR, Enhanced STAR, Senior Citizen and Disabled Homeowners' exemption. The 421a property tax exemption, available for larger residential buildings with at least 3-4 units, reduces assessed value to pre-construction levels for a significant period. Finally, abatements, similar to a tax credit, reduce the tax bill dollar for a dollar. Condo-coop abatement is a major abatement available to owners of condos and coops who use it for their primary residence.¹²

The tax rate, the assessment rate, the market valuation determination and the availability of abatements and exemptions depend on the tax class a property belongs to. Properties in New York City are divided into four tax classes. Class 1 properties include one-to-three family homes. Class 2 properties include large rental buildings, condos and coops, properties that are focus of the analysis in this paper. Class 3 properties include utilities. Class 4 properties include commercial buildings, offices, factories and warehouses. Though both owner occupied units and apartments buildings are residential, they are subject to different tax rates and assessment ratios. While Class 1 properties (family homes) are assessed at 6% of their full market value, class 2 properties (rental units, condos, and co-ops) are assessed at 45%.

The process of development in the city is quite similar to elsewhere. Developers buy vacant land and raise money; obtain one permit from Department of Buildings to begin construction for a single building. They can chose to build family homes, purely rental buildings, or mixed condo buildings.¹³

Property taxes on rental properties in New York City

Property taxes are a significant share of operation costs of rental developments in New York. Tax rates, assessment formula and assessment rate all contribute to the high property tax. Rental

¹¹For example, at the tax rate of say 20%, a household living in a one-family home valued at \$100,000 will pay an annual tax of (Home value)(assessment ratio)(property tax rate) = (\$100,000)(0.06)(0.20) = \$1,200.

¹²See <https://www1.nyc.gov/site/finance/taxes/property-assessments.page> for more details.

¹³There are almost no new co-ops built in recent decades. A co-op is an LLC where the owner of each unit owns shares equivalent to the size of his unit. The co-op board is responsible for the maintenance of the common spaces.

buildings are assessed on the basis of their net rental income, where net rental income is defined as the difference between gross income and operating expenses¹⁴ For this reason, all landlords of rental buildings greater than 10 units are required to submit Real Property Income and Expense form annually where they declare their annual revenues and expenses. The Department of Finance adjusts the net rental income for risk, liquidity and capitalization to obtain their annual market valuation. In general,

$$\text{Annual market value} = [\text{Rental Income} - \text{Expenses}] \times \frac{1}{\text{Capitalization rate}} \quad (7)$$

Capitalization rate is determined annually on the basis of risk, liquidity and management costs. It is equal to 16% on average which suggests a capitalization factor of around 6. Using equations 6 and 7, a tax rate of 5.5% and capitalization factor of 6, we can determine the net tax burden on rental income (net of expenses) generated by the property tax. The effective tax rate on net rental income is given by:

$$ETR = \frac{5.5 \times 0.45 \times 6 \times \text{Net Operating Income}}{\text{Net Operating Income}} = 14.85\%$$

This suggests that close to 15% of the landlord's net rental income per year is spent towards the payment of the property tax. Therefore, the 421a property tax exemption that reduces the tax on new investment is quite valuable to a developer of rental property.

¹⁴In contrast, family homes are assessed on the basis of sales price of similar properties nearby.

A-4 How the tax reform changed property taxes across regions

Note. This Appendix section is based on Singh and Baldomero-Quintana (2026)

This section illustrates that the 2006-08 tax reform of 421a property tax exemption had differential impact on the three regions in Figure 1: *old-exclusion region* (light shaded blue colored), *new-exclusion region* (dark blue colored), and *non-exclusion region* (yellow colored).

We focus exclusively on tax liabilities and we do not consider other elements in these calculations that can influence the decisions of real estate developers such as the new size requirements, the opportunity cost of affordable units, the stricter size requisites of new affordable units, or the preferences of investors regarding provision of affordable units or rent control. In particular, we show that in the light shaded region, the reform effectively removed the tax exemption by making onsite provision of affordable units mandatory. In dark unshaded region, the reform either did not affect tax incentives or it completely removed them, depending on the cost of providing affordable housing onsite. Finally, in the light unshaded regions, the reform did not alter tax exemption benefits significantly, since it simply imposed a cap on the benefits.

Light shaded blue regions (old exclusion region)

Prior to the reform, the developers were required to provide affordable housing but they could choose to do so offsite. By allowing the developer to build offsite in relatively low-rent regions, developers had significant cost savings. Using an example, we show here that taking away the option to provide affordable housing offsite can impose compliance costs under the property tax exemption equivalent to an increase of property tax of around 2 percentage points. Given the statutory property tax rate of around 5.5% faced by a developer that does not claim a tax exemption, the tax-reform effectively made the property exemption in light shaded regions regions unattractive.

Consider an average rental building in an old-exclusion region that has 56 units and can expect to get at least \$34,820 (2015) USD per year from a single market rent unit. In contrast, a developer can expect to get at most \$14,013 from an affordable unit in the building. This is because for a 4 person family, the 50% Area Median Income (AMI) is \$38,400 and therefore, the maximum rent the developer can charge is 30% of this income limit (See HUD source for a list of AMI for different years).¹⁵ Note that the maximum rent the developer can charge in an affordable unit is fixed throughout the city, irrespective of variation in local rents across neighborhoods within the city.

With an onsite affordability requirement, the developer must keep 11 out of 56 units affordable with a discount of $\$34,820 - \$14,013 = \$20,807$ on each affordable unit. The total cost imposed

¹⁵Because AMI varies from year to year, all calculations are based on the 2008 AMI which is converted to 2015 USD. Additionally all calculations are based on income limit for a 4 person family, earning 50% of area median income. After 2012, all affordable units are advertised through the online portal <https://housingconnect.nyc.gov>.

by onsite affordability requirement is therefore, \$228,877, which suggests an effective tax rate of $\frac{228,877}{5 \times 56 \times 34,820} \times 100 = 2.35\%$ when we use a capitalization factor of 5. If we use a higher capitalization factor (e.g., 6), we get an effective tax rate of up to 1.96%. Previously, with the offsite affordability option, this tax rate was effectively zero. Therefore, the 2006-08 reform removed the tax break and thus, increased the effective property tax rate on future projects in light-shaded regions.

Dark unshaded blue regions (new exclusion region)

The major change brought by the reform in dark unshaded regions included the elimination of claiming a short exemptions (15 years) as-of-right. Whether or not the reform effectively altered the tax benefits in these regions depends on whether the second best option—long exemption with onsite affordable housing requirement—is a worse option than obtaining no exemption at all. This in turn depends on how local rents compare with the affordable rent. In low-rent regions, the long exemption would still be a better deal because of low discount on affordable rents. On the other hand, in high-rent regions, a long exemption with affordable housing requirement is less lucrative because of high discount on affordable units. This is because the rent that a developer can expect from an affordable unit is fixed throughout the entire city, irrespective of variation in rents across neighborhoods within the city.

To see why location of a neighborhood within the dark region matters in determining whether the long exemption is profitable, consider the following case. According to the raw data, an average rental building (a building classified as rental walk-up buildings, rental buildings with elevators, or condos) has an annual market value of \$ 3,088,948 in 2015 US dollars. This implies an average annual property tax payment=\$166,803.

The net present value of this sum is given by:

$$NPV = \frac{166803(1 - (1 + i)^{-T})}{i}$$

For $T = 25$ and $i = 15\%$, and no costs, the net present value of long tax exemption is \$1,078,239.¹⁶ However, a developer must keep 20% of the units affordable to households with income of 30-100% of the area median income, which adds to the cost under long exemption. The average annual income from a market rate rental unit in the dark regions in 2008 was about \$12,187 and a building had on average 46 units. For an affordable unit, the developer can expect *annual rental income* of at most \$14,013. This is actually higher than the expected income from the market-rate unit, which suggests on average the costs under long exemption are minimal.

However, the average masks substantial heterogeneity in rents within the dark regions. For in-

¹⁶We use $i = 15$ because this interest rate is consistent with the average capitalization rate used by Department of Finance in calculating market valuation of apartment buildings. They use the capitalization rate to calculate the present discounted value of the *annual rental income*, which serves as the tax base for the property tax calculations for that year. See [here](#), for example. In general, with capitalization rate of 15%, market valuation of a property with rental income R is equal to $\frac{R}{0.15} = 6.6 \times R$. Capitalization rate changes over the years, but is largely in the range of $\{13, 17\}$.

stance, 95th percentile average *annual rental income* is about \$34,423, which is much higher than the affordable rent limit. Annual cost of imposed by an affordable unit is then = $34,423 - 14,013 = 20,410$ and total number of affordable units to be provided = 9. Using the net present value formula, we can see that the annual cost of long exemption for developer is then = \$183,690, higher than the property tax savings under exemption.

Therefore, we can expect the reform to drastically cut tax benefits in high rent regions with no significant change in low rent region within the dark blue unshaded region. This further suggests that the future marginal tax in dark regions either did not change or increased by 5.5% (the statutory tax rate) after the reform.

Unshaded yellow regions (non exclusion region)

The only change specific to tax liabilities brought by the reform in unshaded light regions was the introduction of a cap on benefits under the short exemption. Because these regions are low-rent, the discount on an affordable unit is minimal and the long exemption is the most preferred option which was effectively unaffected by the reform. For instance, an average rental building in yellow unshaded region has an annual market valuation of around 2,755,881 US 2015 dollars and has around 65 units. This suggests that the rental income of the average building is about \$459,313 or around 7,000 per rental unit, much lower than the average income from an affordable unit. Therefore, long exemption imposes non-zero costs and the exemption lasts for a longer duration implying that long exemption is a clear winner in these regions. This further suggests that the change in effective property tax here as a result of the reform was not significant. We still observe that developers rushed to build in these areas due to the implementation of stricter construction requirements to obtain the 421 tax exemption.