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The Economics of Manhattan Skyscrapers

Jason Barr

The skyline, as a collection of skyscrapers, is inherently an economic phenomenon. The heights, frequencies, locations, and shapes of skyscrapers are driven by the costs and benefits of their construction. Government policies, such as zoning, which are aimed at limiting building densities and locations, also influence the returns to skyscraper developers. The aim of this paper is to investigate the relationship between skyscraper construction and its underlying economics in New York City.

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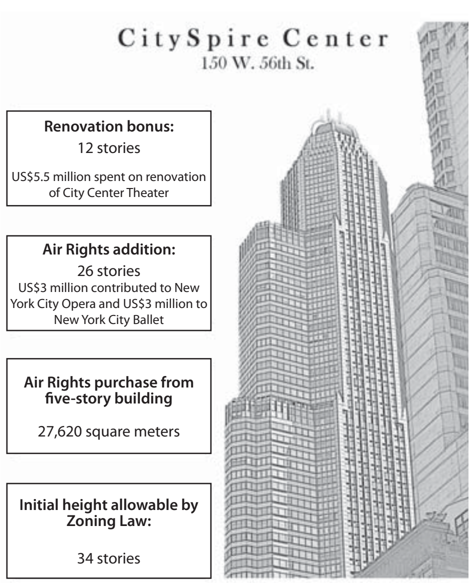

Figure 1. The CitySpire Center (1989), at 75 stories, was able to rise taller than the zoning law allowed because of the purchase of air rights and the provision of neighborhood amenities. Source: Scardino (1986).

The Economic Theory of Skyscraper Height

In order to better understand the economics of skyscrapers, this section discusses the theory of skyscraper height (Barr 2010). The goal is to describe the key factors that drive skyscraper development and filter out many of the smaller details, in order to understand the market for building height in general.

The theory begins by assuming that a developer owns a lot of land in the city that is suitable for skyscraper construction. The profit from development is determined by several factors. First is the average price of space in the city. The relative income from different types of structures will determine which kind will be built. For this model, without loss of generality, the maintenance, operating, and financing costs are ignored.

For simplicity, assume that a developer has to choose between two kinds of structures: an office or a residential condominium (condo). The developer observes the average per-square-foot selling price of new condos, compares it to the average rents being paid for new office buildings, and makes a decision about which one will generate a greater income. For condos, the income comes directly from the sales of residential units. For offices, the income can come from the discounted flow of office rents, or from the sale of the building after completion.

Next, the developer has to consider how tall to build. To answer this question, one must consider three key variables. First is the base price. Second is the height premium; that is, the amount by which income rises with building height. In general, across structure types, height consumers are willing to pay more to occupy the higher floors. While no research has studied the specific reasons for this, one would assume that the height premium is driven first by the better views and the lower street noise, and second, by the social status it confers upon those who occupy space above the majority of the tenants. Being on a higher floor signals that one has more resources to pay for the right, and thus will occupy a more favorable location in the social or economic hierarchy. This height premium is based on the assumption that elevators are able to deliver people rapidly and comfortably to the upper floors.

The third variable is the construction cost. For simplicity, assume that building costs rise at an increasing rate with the density of the building (the number of floors per hectare, for example). That is to say, if a builder has a smaller lot, then building taller will mean that more of the structure will be taken up by elevator shafts, and the narrowness of the structure will require a greater proportion of costs devoted to wind bracing (Ali & Moon 2007). If the developer has a large lot, then it can be assumed that construction costs per floor per square meter are not as great, because the developer has increased flexibility by designing a more efficient space.

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Prof. Jason Barr is the recipient of the CTBUH 2015 Research Seed Funding Award, sponsored in 2015 by Sun Hung Kai Properties for his anticipated research project entitled, **"Skyscrapers and Skylines: The Case of China."**

He is also a poster presenter on the subject of **"The Economics of Skyscraper Construction in Manhattan"** which can be seen on exhibit in the main ballroom foyer during the conference.

The costs of the structure are determined by several factors. First is the cost of materials and labor. As these rise, a builder is less likely to add height to the structure. Second is the time to build, which in New York can be quite long. Time to build includes the time needed to acquire lots and air rights; to get zoning and other regulatory permissions; to plan the project (such as creating the architectural and engineering designs); to establish the supply chain; and finally, to acquire financing and secure early tenants.

But costs are also impacted by technological change, which can improve the efficiency of the construction process and building design. In some sense, the costs of time, materials, and labor are "competing" against the technological changes. That is, technological innovation can lower the time and costs of building, but other forces are at work to increase them, such as rising wages and increased regulatory burdens. As discussed below, the net effect of the two in New York seem to balance each other, though materials and wage costs have risen faster than savings from construction innovations. This is not likely to be the case in other countries, such as China, where material and labor costs are significantly lower and regulatory hurdles are less, all else equal.

Zoning

In the absence of any zoning restrictions, the developer would then choose a height such that at the last floor, the additional or marginal revenue from it would just be equal to the additional or marginal cost of constructing that floor. In other words, the chosen building height is the one at which the income from the highest floor just equals the cost of providing it. All else equal, the height of the structure will be taller as the base price rises, the height premium is greater, and the lot size is larger. The height of the building will fall as costs increase.

New York City zoning regulations, however, limit the bulk of the structure by capping the Floor Area Ratio (FAR), which is the total usable floor area divided by the lot size. For commercial buildings in downtown or midtown, the base FAR is 15; for residential buildings in Manhattan it can be high as 10. As-of-right FAR bonuses of 20% are allowed in the densest districts if the builder provides a plaza or other specified public amenity (NYC Planning 2011).

"By transferring development ("air") rights, the total block density is fixed by the FAR caps, but the distribution of the FAR is established by market transactions."

As an example, let's say a developer has a lot of 2,000 square meters, and is in a FAR district of 15. The developer can choose to construct a 15-story structure, where each floor is 2,000 square meters; a 30-story structure, where each floor area is 1,000 square meters; or a 60-story structure with a 500 square-meter footprint. In other words, the developer can choose a short and bulky structure or a narrow and tall one, or something in between. The decision about how to allocate the floor area will be based on the underlying costs and benefits of doing so.

If the profit-maximizing height, as described above, produces a building density that is greater than the FAR limit, the developer must reduce the bulk to be in conformity with the law. If we assume that developer is going to build a glass box-type structure with the same floor area for each story, then the problem boils downs to choosing the building footprint size. The building height (number of floors) is then derived from the footprint size (in square meters) times the FAR. On average, building height will be positively related to the FAR limit.

The Air Rights Market

Under New York zoning rules, if a landlord owns an older structure that has a lower FAR than the law allows, that owner can sell the difference between the maximum FAR and the building's actual FAR to owners of adjacent lots. The idea is that by transferring development ("air") rights, the total block density is fixed by the FAR caps, but the distribution of the FAR is established by market transactions. In addition, specific landmarked districts allow for the sale of air rights from older, landmarked buildings to provide income for preservation (NYC Planning 2015). In this case, a developer can purchase more floor area for the structure; this is tantamount to raising the FAR limit imposed by the city, which will then generate a taller structure, since building height is positively related to the FAR limit.

Figure 1 illustrates a case with the CitySpire Center (1989), at 150 West 56th Street in Manhattan. The developer acquired a plot of 2,250 square meters, and the maximum FAR was 15. The underlying economics would have meant that a 34-story building would be constructed. However, the developer, Ian Bruce Eichner, was able to acquire more floor area through two mechanisms. First was the purchase of air rights from a neighboring property (which gave the equivalent an additional FAR of about 12). Second, by providing several amenity bonuses, the developer was able acquire more floor area by helping to improve nearby public institutions. In the end, the structure was able to rise 75 stories, and has an FAR of 29.

In summary, the theory predicts the following results. First, the type of structure will be determined by the relative income from different kinds of buildings at a particular location. Second, the height of the structure will be determined by the average price of space, the size of the height premium, and the costs and time of construction. Third, zoning rules will influence height; the greater the FAR cap, the taller the building. Fourth, air rights will influence height; when air rights are more abundant and/or relatively inexpensive, building height will be taller. Further, we would expect the price of air rights to track the base prices; as revenues from construction rise, it suggests that air rights are more valuable and developers will bid up their prices. Actual heights will vary from the theoretical predictions because of particular decisions related to design, engineering, and/or other city regulations.

Lastly, one note is in order. In the economic theory of building height, land values do not play a role. The reason is that from an economic point of view, building height is determined by the point at which the additional or marginal costs of construction just equal the marginal benefits. Since land is a fixed cost, it does not influence the height calculus. Land values are determined by the profit-maximizing height, not the other way around. Of course, to the developer, land costs are a large expense; and as land values rise, the developer has an incentive to build taller to recoup these costs. Though this is beyond the scope of this paper, it can be demonstrated mathematically that under some general assumptions land values and height will be the same, either from the economic perspective or a developer's return-on-investment analysis (Barr, Forthcoming).

Manhattan Skyscraper Market, 1990–2015

This section discusses the market for skyscrapers in New York and how it relates to the economic theory discussed above. Figures 2 and 3 present information on skyscraper construction in New York City from 1990 to 2014 (Barr 2012); data was updated from the same sources. First, Figure 2 shows the total meters of skyscraper height added to the skyline each year. Here, a building is considered a "skyscraper" if it is 90 meters or taller. The figure also presents a two-year moving average, which smooths out the year-to-year fluctuations.

As the figure shows, total height additions have moved in waves. From 1990 to 1997, the city was facing declining additions, likely due to the economic recession of the early1990s. Then there was a long cycle of increasing construction from 1998 to 2012, with a peak in 2010. There's little evidence to suggest the terrorist attacks of 9/11 impacted the larger market. The financial crisis of 2007 seems to have taken a while to manifest itself in the height market, with a nadir reached in 2012. Since then, the city has resumed upward momentum.

Figure 3 shows the tallest building completed between 1990 and 2014. In terms of the height cycles it shows a similar picture, with a fall in height to 1997, followed by rising height to about 2010 or so. The completion of One World Trade Center (541 meters) in 2014 has given the city the title of "Tallest Building in the Western Hemisphere." The graph suggests that the height of One WTC was made less with economics in mind, as it represents a large deviation from the heights that preceded it. At 1,776 feet, its height was chosen for symbolic reasons.

Figure 4 shows the number of completions in Manhattan each year, separated by type. Over the last 25 years, the predominant structure type has been residential (which can be either rental units or condos). Offices, hotels, and mixed-used buildings comprise the majority of the rest (the other group includes hospitals and government buildings). The black line on the graph shows the percent of skyscraper completions each year that are residential, which, over the period, have comprised 61% of all completions. Offices are a small minority of the total market; this is ironic, since it was office construction that gave birth to the skyscraper and sustained its early growth in Manhattan (Barr, Forthcoming).

Skyline Growth: An Economic Analysis

This section aims to understand what has influenced the changes in skyline growth over the last 25 years. Another way of asking this is: What does the evidence say about the different factors that are described in the theory?

The price of space

The first component is the base price of space. Figure 5 shows indexes of the real (inflation-adjusted) value of condo apartments and asking rents for Class "A" Manhattan office space in Midtown since 1995.[1] The two indices have been normalized so that 1995 is set to 100. The figure shows that the real values of condos (in all buildings, not just high-rises) have risen at a much higher rate. Between 1995 and 2002, the two series tracked each other, but since then, apartment prices have risen much faster, and there remains a wide disparity between the

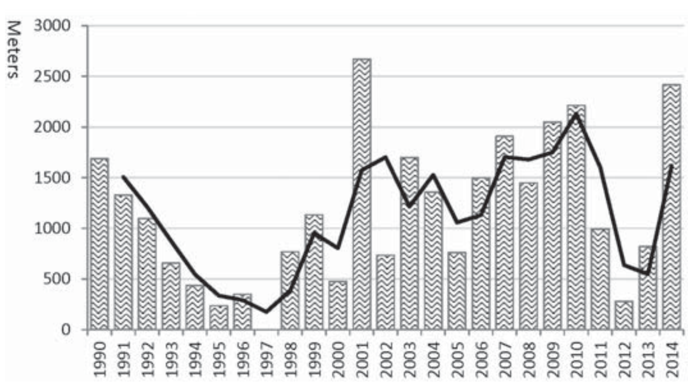

Figure 2. Total skyscraper height in meters added to the Manhattan skyline each year from 1990 to 2014. The black line is the two-year moving average. For this study skyscraper is considered a building that is 90 meters or taller.

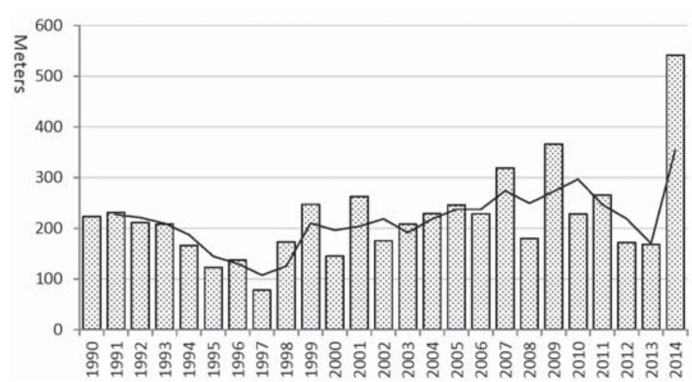

Figure 3. Height of tallest building in meters completed each year in Manhattan from 1990 to 2014. The black line is the two-year moving average.

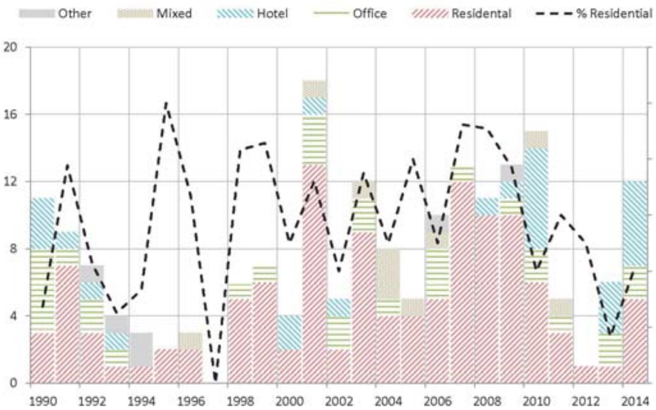

Figure 4. The number of skyscraper completions in Manhattan from 1990 to 2014 separated by building type (left axis). As the figure shows, in the last quarter century, residential buildings have made up the majority of new construction. The black line is the percentage of new construction that is residential (right axis). For this study skyscraper is considered a building that is 90 meters or taller.

	(1) # Completions	(2) Ln(1+# Completions)	(3) Tallest Height	(4) Ln(Tallest Height)
Variable	Poisson	OLS	OLS	OLS
Ln(Real Condo Index) (t-1)	0.76 (1.09)	1.12 (0.86)	140.1 (72.9)*	0.83 (0.35)**
Ln(Real Office Index) (t-2)	1.51 (0.54)***	1.56 (0.70)**	-10.20 (123.3)	-0.01 (0.47)
Ln(Turner Index) (t-2)	-0.48 (1.27)	-0.98 (1.39)	17.5 (161.8)	-0.28 (0.56)
Constant	3.12 (5.92)	4.54 (6.09)	-641.4 (925.2)	2.77 (2.99)
Pseudo R^2/ R^2	0.16	0.42	0.30	0.41
Adjusted R^2		0.30	0.17	0.29
# Obs.	19	19	19	19

"Ln" is the natural logarithm, "OLS" means the equation was estimated by ordinary least squares regression
***Stat. sig. at 99% level **Stat. sig. at 95% level *Stat. sig. at 90% level

Table 1. Regression results for number of completions and tallest completed building each year from 1995 to 2014. Robust standard errors are below each coefficient estimate.

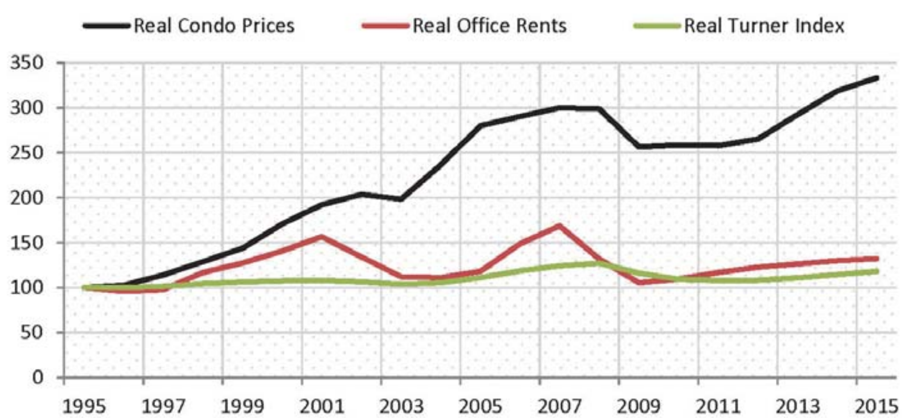

Figure 5. Indexes of the real price of Manhattan condos, office rents, and construction costs (Turner Index) from 1995 to 2015 (Q1). 1995=100.

two. The figure also shows the Turner Construction Cost Index (TCCI), which estimates building materials prices, labor costs and productivity, and "the competitive condition of the marketplace" (Turner Construction 2011), adjusted for inflation.

But the question remains: how is skyscraper construction influenced by the two types of prices? To this end, a series of regressions was run for the period to see how the number of skyscraper completions and the tallest building were influenced by condo prices, office rents, and construction costs (see Table 1). While the sample is admittedly small, the results suggest that the number of completions is determined by increases in both the condo prices and office rents. Equation (1) is the result of a Poisson regression that looks at how the number of completions is influenced by prices. Equation (2) investigates the natural logarithm of one plus the completions count. Equation (3)[2] studies the height of the tallest building completed each year; and Equation (4) looks at the natural log of the height of the tallest completed building.

The independent variables are all in natural logs, which means that the coefficients determine how the dependent variable changes with a 1% change in each of the right-side variables, respectively. Also notice that these variables are lagged one or two years to account for the time to build. For example,[3] Equation (1) shows that when there is a 1% increase in the real office index, then, on average, two years later the number of completions increases by 1.51.

Equations (1) and (2) provide evidence that the number of completions responds positively to both condo and office prices. Given the small sample, it's difficult to infer the exact responsiveness from these two variables, but the evidence suggests that the number of completions has been driven in large part by the rise of condo prices in the city, since condo prices have increased quite rapidly in the last two decades.

[1] The condo index was created by regressing the natural log of real condo prices per square foot (using the NYC CPI) on the apartment square footage, a dummy variable if the unit was less than 400 square feet or not, the floor, a dummy variable if the unit was a penthouse or not, year dummy variables, and building fixed effects. The index was created by taking 100 times the exponent of the year dummy coefficients. 1990 was the omitted year is thus set to 100. All coefficients were statistically significant at greater than 99%. The regression included 68,422 sales between January 1990 and March 2015. Regression results are available upon request. Data is from the StreetEasy.com website. Asking office rents for midtown Manhattan Class "A" office space was taken from various industry reports. The nominal asking rents were divided by the NYC CPI and then normalized so that 1995 was equal to 100.

[2] One is added to the completions count for all years before applying the natural logarithm so that the year with zero completions can be included. This adjustment has minimal effect of the results.

[3] Lag lengths were chosen based on trial and error, and those that generated the highest adjusted-R^2 are presented.

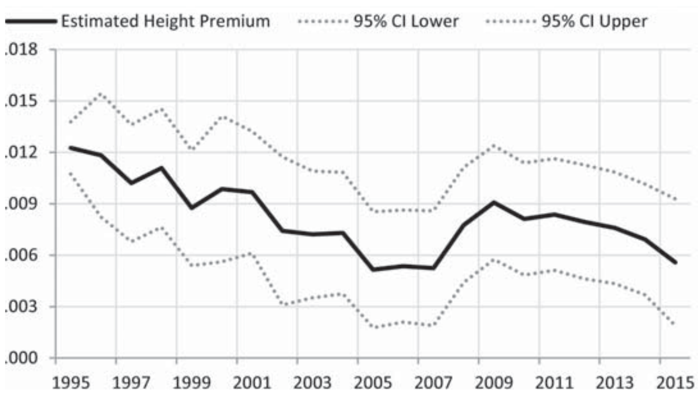

Figure 6. Changes in the estimated height premium over time for buildings that are 30 stories or taller in Manhattan from 1995 to 2015 (Q1). Confidence intervals of 95% are also included.

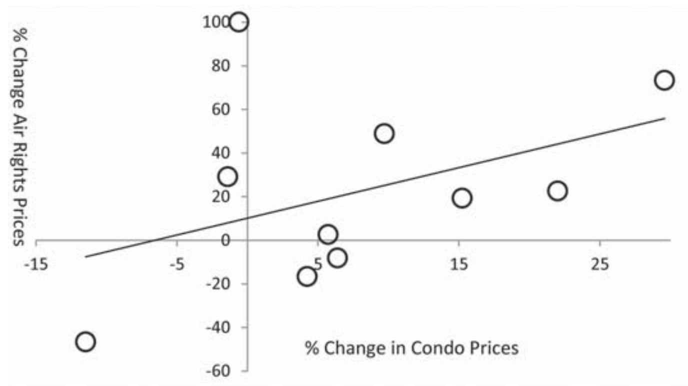

Figure 7. The percent change in average per-square-foot air rights prices versus the percent change in average per-square-foot condo prices in Manhattan between 1994 and 2013. Note that the correlation coefficient between the two is 0.42. The black line is the trend line.

For the tallest building equations, the results suggest that office rents have not been driving the height of the tallest buildings in the city, but rather are a result of the rise in residential prices. This conclusion comes from the fact that the estimated coefficient for the condo index is positive and statistically significant; while the coefficient for the office index is negative and statistically insignificant. Equation (4), for example, shows that, on average, a 10% increase in real condo prices is associated with an 8.3% rise in the height of the tallest building a year later.

Lastly, the results show that builders reduce the number of skyscrapers when construction costs rise, as measured by the (national) TCCI.

However, the height of the tallest building seems less responsive to costs. Returning to Figure 5 shows that real construction costs, as measured by the TCCI, has been relatively flat over the last quarter century. This finding, combined with the coefficients estimates in Table 1, suggest that building activity in the city has not been fundamentally affected by the cost side. Figure 5 indicates that materials and labor costs are perhaps rising a bit faster than the pace of productivity improvements.

The height premium

The above results imply that increases in skyscraper completions and heights are coming from the rising profitability of residential development in particular. The next question, though, is how much of this is being driven by the base price of space versus a possible increase in the height premium? That is to say, is there evidence that consumers value height more over time, and thus developers are responding not so much to a rise in the base price, but rather to the fact that those who occupy higher floors are more eager to outbid those on lower floors?

Since the regression results that generated the condo price index also included the story of the unit, the height premium can be obtained, and furthermore, the question can be answered if the height premium has been rising over time. Two sets of results are presented. First, Table 2 shows estimates of the height premium (i.e., the average percent rise in price for the next-highest floor, holding constant other factors that determine sales prices). The table shows that, across subsamples, the height premium ranges between 0.73% and 0.93% per floor. In other words, on average, an apartment that is 10 stories higher than another one in the same building is expected to sell for 7.3% to 9.3% more, all else equal.

The first result is for all buildings in the sample, where buildings could be of any age and height. The results show that across Manhattan, the height premium is about 0.93% per floor. The other results show that the height premium for newer buildings in general, and for newer tall buildings, is less than all buildings in the city. The reason for this is left for future work. However, there's no evidence that the heights of buildings in Manhattan are being driven by a change in the height premium.

Figure 6 also shows the evolution of the height premium since 1995 for buildings that are 30 stories or taller. Recall from Table 2 that the average height premium for these buildings is 0.86%. Figure 6 shows estimates for changes above or below that average over time. Note that the entire sample contains 1,144 buildings; though only 10% are 30 stories or taller, they contain 38% of the units. Between 1995 and 2007, the premium was falling, and then began to rise until 2009; it has stabilized since then, but has a fallen a bit since 2013. It appears the premium is tied to changes in the economy in general but, again, investigation of the willingness to pay for height is left for future work. There is little evidence to suggest a major structural change in the height premium in the last decade for the tallest buildings in the city.

Air rights

Data on air rights purchases is hard to come by, though there are a few studies on the market in general. Between 2003 and 2013, the average value of air per square meter in Manhattan has risen from US$807 to US$3,229 per square meter. In the same period, the average price of condos in Manhattan has risen from US$7,308 to US$14,359 per square meter (Morris 2014).

Figure 7 shows the percent change in per-square-foot air-rights prices versus the percent change in the average per-square-foot condo prices in Manhattan. As the figure demonstrates, there is a relatively strong correlation between the two. As the price of condo space has risen, it has pushed

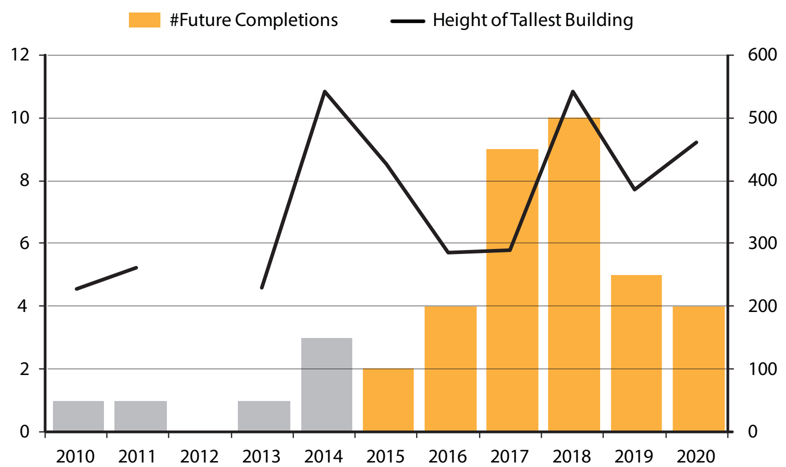

Figure 8. Estimated number of 200-meter or taller buildings expected to be completed between 2015 and 2020 in New York (left axis). The black line is the estimated height of the tallest building to be completed in these years (right axis). Source: CTBUH Skyscraper Center.

Sample #	Regression Sample	Floor Coefficient	# Obs.
1	All buildings	0.0093 (0.0002)***	52530
2	Built since 2000	0.0084 (0.0003)***	8472
3	30+ stories	0.0086 (0.0002)***	20476
4	Built since 2000 & 25+ stories	0.0073 (0.0003)***	4207
***Stat. sig. at 99% level			

Table 2. The estimated height premium for different condo sales samples using ordinary least squares regression; other variable coefficient estimates are not shown in the table. The entire sample includes sales in Manhattan between January 1995 and March 2015. Robust standard errors are below each coefficient estimate.

developers to purchase more air rights (and bid up the price) to reap the returns from the increased price of residential space.

The Future

Speculation about the future is always a risky endeavor. However, one can find some clues for the near-term future for Manhattan (The Skyscraper Center 2015). Figure 8 gives the number of recent and expected completions of 200-meter or taller buildings in New York from 2015 to 2020. Since 2010, only four 200-meter or taller structures have been completed. However, from 2015 to 2020, this is likely to rise to 31. The figure also shows the height of the tallest building expected to be completed each year over the period; it hovers around 420 meters, on average.

The resurgence of the Manhattan skyline seems to be driven by a few key factors. Regarding office construction, the city has experienced rising office rents, and it has not built a significant number of new office buildings since the late 1980s. As such, Manhattan is primed to construct new office buildings to replace its aging stock, such as the Hudson Yards projects over the railroad tracks west of Penn Station.

The resurgence in residential skyscraper construction is due, first, to increasing income inequality and the rising share of wealth going to the top 1% of society (Barr, Forthcoming); and second, from the perceived safety of Manhattan real estate investments by the international community (Story & Saul 2015). In large part, investments in supertall luxury buildings have been by ultra-wealthy international investors, who both enjoy the cachet of owning Manhattan real estate, and who seek to invest their wealth outside of their home countries. For example, 77% of condo buyers of the newly-completed One57, a 75-story tower near Central Park South, have been purchased by shell corporations to shield the names and assets of the owners (The New York Times 2015). While we can see these recent trends in wealth accumulation and allocation are good for the Manhattan skyline, it's another matter altogether whether they are good for the city in general. But that question is left for future research. ■

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"Increases in skyscraper completions and heights are coming from the rising profitability of residential development in particular."