Skyscrapers and the Skyline: Manhattan, 1895-2004*

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Abstract

This paper revisits an issue not studied since the 1920's: the economic determinants of skyscraper height and completions. I study annual average heights and the number of completions in Manhattan from 1895 to 2004. First a simple model is given to provide equations for the optimal number and height. Then these equations are empirically estimated. I find that, fundamentally, the market for skyscrapers has not changed over the course of the 20th century; their major cycles are determined by the ebb and flow of supply and demand variables, such as office employment, population, building costs, zoning regulations, and property taxes and subsidies. Counter-factual predictions are also provided to estimate the effect of government policies on skyscrapers.

JEL Classification: N61, N62, R11, R33

Key words: Skyscrapers, building height, Manhattan

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1 Introduction

Skyscrapers have captured the public imagination since the first one was completed in Chicago in 1885. Manhattan soon took the lead in the race to build the world's tallest buildings; and ever since the late nineteenth century, the Manhattan skyline has become the key symbol of New York's economic might.[1] Though the existence and development of skyscrapers and the skyline are inherently economic phenomena, surprisingly, little work has been done to investigate the economic factors that have determined this skyline.

For roughly eighty-five years, New York City had the world's tallest building.[2] Despite the fact that New York City does not currently have the world's record, it has continued to be one of the largest producers of skyscrapers. New York's rise to skyscraper prominence in late-19th and early-20th centuries was due to its economic centrality and its policies about land use. Since World War II, that New York has continued to generate skyscrapers in such numbers is due to both its continued role in the world economy, and because of the city's policies of offering tax abatements to developers (in part due to high land costs).

The last time that economists have studied skyscrapers in any significant detail was during the building boom of the late 1920's. At the time, there was a debate about whether the unusually tall buildings being erected (e.g., the Empire State Building, and the Chrysler Building) were some how "freak" buildings, built, not based on sound economic principles, but rather on non-profit maximizing motives, such as the desire of builders to show off their wealth or to compete in the race to be the word's tallest building.

The work of Clark and Kingston (1930) showed, however, that the height of buildings in general, at the time, were consistent with profit maximization, given the current rent levels, land values, and the cost of building in the late 1920's. Their work demonstrated that building height is, at its heart, an economic variable. Since that time, to the best of my knowledge, there has been no systematic study of the determinants of skyscraper production or height in any city.

This paper revisits the issue of optimal skyscraper height, using new data and standard regression methods, which were unavailable at the time.

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[1] The attacks of September 11, 2001 clearly demonstrate the symbolic importance of New York City's skyline for both the city and the U.S.

[2] New York City began its record-holding in 1890 with Joseph Pulitzer's World Building and lost the record in 1974, with the opening of the Sear's Tower in Chicago.

Though the costs and benefits that have determined the decision about whether to build and how tall to build have varied over the course the twentieth century, this paper demonstrates that there has been no fundamental change in the skyscraper building patterns over the 20th century. Though the 1920's represented an aberration in terms of the number of skyscraper completions at its peak, the forces driving the average heights of buildings, however, have not changed significantly over the 20th century. Rather the average height is based on the supply and demand for this height, which is determined by factors related to both the New York City and national economies, regulations on land usage, and taxation. That is to say, the fundamental conclusions of Clark and Kingston still remain valid today.

Most popular and academic accounts of skyscrapers (with the exception of Willis, 1995) fail to make the important distinction between *engineering height* and *economic height.* The technological capability and know-how to construct very large buildings (engineering height) were essentially in place by the 1880's; however, the costs and benefits of skyscraper development (economic height) have varied dramatically over the years.

In Manhattan, for example, since 1894, there have been five major skyscraper building cycles. Based on the data set (discussed below), the average duration of the first four cycles has been about 26 years (the 5th cycle is still ongoing), with the average heights of completed skyscrapers varying accordingly.[3] Table 1 lists the periods of these cycles. The fact that major skyscraper cycles last, on average, a quarter of a century, indicates that their construction (and heights) are determined by major economic, demographic and political forces, rather than simply the ebb and flow of production and consumption.[4]

For the purposes of this paper, I define a "skyscraper" as a building that is 100 meters or taller, as determined by the international real estate consulting firm Emporis.[5] Clearly, over time, the definition of what constitutes

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[3] While skyscraper cycles appear to have some similarities to overall building cycles in Manhattan, they have distinct characteristics them make worthy of study in their own right. This conclusion is based on a comparison skyscraper completions to annual new building permit issuances and annual office building completions. Permit and office data are available upon request.

[4] Since 1893, there have been there have 24 business cycles in the United States, as measured by the National Bureau of Economic Research (http://www.nber.org/cycles.html/).

[5] The measure of building height used here is structural height, which does not include any additional antennae or decorative elements. The average number of floors for a 100 meter building is 30. In fact, we can predict the number of floors from the height by the

Cycle	Period*	# of Years	Year of Peak
1	1894-1919	26	1915
2	1920-1945	26	1931
3	1946-1978	33	1971
4	1979-1997	19	1987
5	1998-	-	-
Avg. cycle length		26.0	

Table 1: Major Skyscraper Building Cycles in Manhattan. *Trough to trough. Source: Author's calculations based on data acquired from Emporis.com. See section 5 for the time series graph of completions and average heights.

a "skyscraper" has changed, but since my motivation is understanding the economic determinants of these buildings, and since they have been regularly built since 1895, I have chosen 100 meters as the cut-off point. Using some relative measure to determine a skyscraper, such as a building's deviation from the mean building height is too difficult to measure over such a long time span.

A skyscraper is qualitatively distinct from other types of structures. The knowledge and skills needed to construct them are very specific and complex. Approval from many city government agencies is needed; only a handful of builders (and their lawyers) have the knowledge and resources to negotiate the arcane city bureaucracy (see Jonnes (1981) and Salmans (1984), for example). The engineering and architectural complexities involved with skyscraper construction also require the hiring and management of very specific talent (Sabbagh, 1989). The process of land assembly in Manhattan also requires a very detailed set of skills, from both a legal and real estate point of view. It is because of these complexities and the large costs that skyscraper construction in Manhattan, historically, has been dominated by a small group of locally-based, family-run companies (see Samuels (1997), for

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OLS-derived equation:

$$\widehat{floors} = \underset{(5.36)^{***}}{5.82} + \underset{(29.9)^{***}}{0.225}\ meters$$

$$R^2 = 0.76,\ \#\ obs:\ 472$$

***Stat. sig. at greater than 99%. Robust t-stats. below estimates.

example). These buildings require vast amounts of capital, both equity and loans; and to amass this capital often requires that the builder assemble a consortium of different types of investors, including banks, insurance companies and equity partners, both local and foreign.

In regard to height, developers face a choice about how high to build since they face a tradeoff between bulk or height for a given plot size.[6] Adding height generates additional rent, status opportunities and great views, but comes with increasing marginal production costs. In New York City, the construction of tall buildings reflects the demand for dense office and housing space, in a market where land costs are high, and where agglomeration economies are great. Relative land scarcity in Manhattan is particularly severe since it is a long but narrow island, and the 1811 gridplan (discussed below) inadvertently put limits on the size of large building plots. As a result, building height is relatively more important in the contribution to total rental space than is the horizontal area. Adding extra height is a way for developers to reap extra profits and satisfy the wants and needs of height "consumers," who demand height for the value and utility it brings.

Tall buildings confer status upon the builders themselves, as they are a form of "conspicuous production." And it is the stories of these builders that have garnered much of the attention in the skyscraper literature. Such buildings include the Woolworth building (1913), the Empire State building (1931), the Twin Towers (1973), and Trump World Tower (2001). But conspicuous production alone does not fill buildings; if the building is not a "machine that makes the land pay" (Gilbert, 1900, p. 624) then its visual impact can be considered superfluous.

In addition, major corporations use skyscrapers as a location for their headquarters, as a form of advertising, and as a means to signal economic strength. Such buildings include the Metropolitan Life Insurance Company Tower (1909), the RCA Victor Building at Rockefeller Center (1933) and more recently the Time Warner Center (2004). These buildings often have the company's logo or name on the very top of the building, or have dramatic architectural elements to increase their recognizability in the skyline, such as the "Chippendale" pediment on the AT&T (now Sony) building (1984), and, the Chrysler Building (1929), with its famous stainless steel spire. These dramatic visual elements, however, only reinforce the underlying economic

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[6] Barr (2007b) looks at the determinants of height at the building level. The study here focuses on annual completions and average heights, and hence their cyclical behavior.

factors creating these buildings: the demand for space and height.

To investigate the nature and determinants of skyscrapers, this paper studies annual skyscraper building in Manhattan from 1895 to 2004, focusing on two related variables: the number of completions, and the average height of these completions. I first provide a simple model of the market for skyscrapers, which gives equations for the optimal height and number. These equations are then empirically estimated over the 110 year period.

As the regression results demonstrate, the market for skyscrapers can be understood by looking at two sets of factors. First is the economic, market-based activity that creates the supply and demand; the second is the set of government policies in regard to land usage, taxation and construction that have altered the economic incentives. I am able to measure the degree to which builders have responded to policies. In particular, since the mid-1970's, city government building subsidies have a played an important role in promoting skyscraper construction.

The rest of the paper proceeds as follows. The next section provides a very brief review of the major economic and institutional factors that have affected skyscraper development in New York City. Then section 3 reviews the relevant literature. In section 4, I give a simple model for the market for height. Then section 5 presents the results of the time series regressions. Section 6 demonstrates the models' predictions as well as some counter-factuals. Section 7 is devoted to concluding remarks.

2 Skyscrapers Building in Manhattan

The rise of an office-based economy during the mid- to late-19th century and the tremendous population and economic growth of New York City generated a demand for building space to house offices and residences. By the late- 19th century, the technological capabilities existed to supply this space, which needed to be in the form of highrise buildings. New York City's 1811 gridplan–which established a standard lot size of 25' by 100'–inadvertently caused relative land scarcity, by making assemblages for tall building more difficult (Willis, 1995). Perhaps the two most important technological innovations were the elevator (and safety break) and the use of steel for building frames, which replaced heavy, load-bearing masonry (Landau and Condit, 1992).[7]

By the early part of the twentieth century, the economic realities that created the Manhattan skyline had also generated concerns that these buildings were blocking the valuable sunlight of nearby buildings and casting shadows on the streets (and generating too much traffic congestion), and therefore depressing property values. The first generation of skyscrapers were not subject to any height or bulk regulations; and developers felt free to build very tall buildings that maximized the total rentable space by using as much of the plot area as possible (Willis, 1995). As a result of the emergence of skyscrapers, starting in 1916, New York City implemented the first comprehensive zoning legislation that stated height and use regulations for all lots in the city. (See Revell (1992) for more details about the zoning plan.)

The zoning code did not regulate height *per se*, but rather generated setback requirements. After reaching a certain height, the building had to be set back. The top floors could be built as high as the developer wanted, as long as the area of those floors were not more than 25% of the area of the lot. The regulations generated the so-called wedding cake style buildings of the 1920's and 1930's.

In 1961, New York City implemented a new, updated zoning law. Like the 1916 resolution, building height was not restricted *per se*, rather the new zoning resolution established limits on the so-called floor area ratio (FAR). The FAR is a multiple of the plot area, that dictates the maximum amount of constructible building area for each square foot of lot size. A FAR of 10, for example, means that on a 10,000 square foot lot, 100,000 square feet of building space can be produced. The builder has the prerogative about how to distribute this space between larger floor area or building height. In addition, the code permitted FAR bonuses if a developer provided a public plaza.[8]

Since 1961 there have been several adjustments to the regulations. For example, from 1982 to 1988, a special midtown zoning district was created to encourage development on the west side of midtown by allowing FAR bonuses of up to 20%. The provision, however, was also accompanied by restrictions on how much sun light could be blocked by the top floors of the building, requiring that 75% of the sky surrounding a new building remain open.

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[7] New York permitted steel frame construction in 1887.

[8] For the office districts in Manhattan, such as near Grand Central Station or lower Manhattan, the FAR was normally 15; if the developer included a plaza then the FAR would be raised to 18.

Starting in the 1970's, a series of building-related subsidies were introduced to stimulate both business and residential construction. In 1977, the Industrial and Commercial Incentive Board (ICIB) was authorized to grant tax abatements to businesses if they constructed offices (or hotels) in New York City. The Board granted abatements to such companies as Philip Morris and AT&T. Starting in 1984, the Board was disbanded and the program became the Industrial and Commercial Incentive Program (ICIP), which provided business subsidies "as of right," if the business satisfied a certain set of criteria. In the mid-1990s, the ICIP program was curtailed in Manhattan, but mayors since then have negotiated tax abatements directly with several companies, such as Bear Sterns and Conde Nast, to occupy newly constructed office space in Manhattan.

In terms of housing subsidies, in 1971 the "421-a" program was introduced to provide tax abatements to building developers for constructing apartments. For builders of rental units, the builder would qualify for the subsidies if they agreed to charge rents within New York City's rent stabilization program. Developers of condominiums could also qualify for the abatements, and the savings could then be passed to the buyers. The program was curtailed for most of Manhattan in 1985; today 421-a benefits are provided to developers only in exchange for the provision of low income units.

3 Related Literature

3.1 Early Work on Skyscrapers and Building Cycles

As discussed above, the work of Clark and Kingston (1930) showed, for example, that, in general, the height of buildings in the 1920's were optimal given the market conditions of the time.

Long (1936) investigated building cycles in Manhattan from 1865 to 1935. He found that there where two major cycles that lasted 37 and 20 years, respectively. Using simple statistics, he investigated the relationship between building construction and stock prices, the interest rate, and industrial profits. Interestingly, he found no relationship between the interest rate on new mortgages and changes in construction, nor does he find any relationship between stock prices and construction patterns. This leads him to conclude that an element of "speculative psychology" and possible "promotional gains" are driving office building at the peak of the cycles (p. 190).

Perhaps the classic work in the field on land values and long building cycles is Hoyt (1933/2000), who detailed the value of Chicago land over 100 years. Hoyt documented roughly 18 year cycles, based primarily on the ebb and flow of population and business in Chicago. While he did not directly address the nature of expectations, Hoyt demonstrated the repeated boom and bust behavior of urban real estate cycles.

Like Clark and Kinston, this work revisits the notion of optimal height; here, though, using regression techniques I measure the degree to which the long cycles are affected by both local and national factors, such as office employment population and stock market activity. Similar to Long I find relatively long major cycle periods, and only a small (though statistically significant) relationship between construction and interest rates. However, the work here demonstrates a significant relationship between stock market activity and skyscraper construction.

3.2 Recent Work on Real Estate Cycles

In the last twenty years, there has been much work exploring the nature of real estate cycles using standard supply and demand models, though none of this work explores the economics of building height.[9] Much of the literature focuses on the debate whether the real estate market is best captured by models of myopic or rational expectations. The empirical evidence indicates that construction cycles behave in a way that is not compatible with builders having rational expectations, in the sense defined by Muth (1961). Work in this vein includes Wheaton (1987; 1999), Case and Shiller and (1989), and Clayton (1996).

Wheaton (1987), for example, investigates national office market cycles from 1960 to 1986. He finds a cycle length of roughly 10 years, "a length too long to be accounted for by realistic construction lags" (p. 282). While Wheaton (1999) concludes that a model of rational expectations induces cycles that are not nearly as extreme as those observed in the data. Case and Shiller (1989) and Clayton (1996) reject the rational expectations hypothesis for housing markets.

Because of the strong evidence found in the real estate literature that construction and price behavior are more consistent with a myopic model

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[9] There is also related work estimating vector autoregression forecasting models, such as McGough and Tsolacos (1999) and Kling and McCue (1987).

rather than a rational expectations model, I assume that skyscraper developers do not use the forward-looking expectations model, but rather make decisions based on the current economic environment. This is not to say that developers are not possibly using a rational expectations model or that they are not forward-looking, but, based on the previous work discussed above, the results presented below, and the work done in Barr (2007a), the "present-looking" model appears to better describe the behavior of developers, given the fact that skyscraper construction has long building lags, requires large capital investment and is semi-irreversible.

In recent years, there has been a series of papers that discusses the role of options pricing theory in the decision to build office space (Titman, 1985, Grenadier, 1995; Schwartz and Torous, 2004; Holland, *et al.*, 2002.) One common theme of this work is that the value of the option to build depends on the level of building value uncertainty. An increase in uncertainty means that the value of vacant land will go up, and, therefore builders are less likely to commit to development. However, Bar-Ilan and Strange (1996) demonstrate that with investment lags (long delays to completions) and the option to abandon the project before full completion (as is somewhat possible with skyscrapers) will, in fact, reduce the incentives to delay the project, since the opportunity cost of waiting increases with long lag times. Thus the net effect of uncertainty on skyscraper development is uncertain given the lag time between project formation and completion.

In the vein of Holland, *et al.* (2002), a measure of "total uncertainty" (or uncertainty with respect to rent values) is created to test its effect on completions and height. As will be discussed below, since I don't have rent values, I use a proxy measure of economic activity that affects rents to look at how the standard deviation of this measure effects completions and height. For completions, uncertainty does appear to be negative, but it does not seem to affect height.

4 The Market for Skyscrapers

This section provides a simple model of the market for skyscrapers to generate equations for the optimal height and number of completions. These equations are estimated in section 5.

A potential developer of a skyscraper faces the following profit function:[10]

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[10] The data set below contains several types of buildings, including offices and apartment

$$\pi_t = V_t A_{t-n} M_{t-n} - C_{t-n} A_{t-n} \left(\frac{M_{t-n}}{A_{t-n}} \right)^2 - A_{t-n} L_{t-n}, \tag{1}$$

where $V_t = \sum_{\tau=t}^{\infty} \left(\frac{1}{1+r}\right)^{\tau} P_{\tau}$ is the per square foot value of the building at time t, the time a developer begins collecting income from the building; P_{τ} is the net rental price per square foot, and r is the real discount rate. For the time being, take V_t as given.[11] Building decisions are made at time $t-n$. A_{t-n} is the area of the plot, M_{t-n} is the height of the building (in meters), and C_{t-n} measures the cost of construction. Finally L_{t-n} is the square foot cost of acquiring the land.[12]

A developer will start reaping returns at time t for decisions made at time $t-n$, since there is a lag between the decision to build and when the building can start collecting rent. I assume, in accordance with Clark and Kingston (1930), Picken and Ilozor (2003) and Sabbagh (1989), that building costs are quadratic with respect to height per square foot. This profit function represents that fact that for a given plot size, the costs to building higher have increasing marginal costs, due to increased cost of elevators, HVAC systems, wind bracing and foundation preparation. The function also reflects that fact that a flat, bulky building is generally cheaper to build than a tall, narrow one of the same volume.

Given equation (1), the first order condition with respect to M_{t-n} yields a decision about the optimal height, which is a function of the value of the building and the building costs:

$$M^*_{t-n} = \frac{1}{2} \left(\frac{V_t A^2_{t-n}}{C_{t-n}} \right), \tag{2}$$

assuming that profits are greater than or equal to zero.

Next, I assume the standard zero profit condition for the value of land: the landowner will charge the developer a price for land such that there are no economic profits. If we set the profit equation (eq. 1) equal to zero, substitute in equation (2) and solve for L_{t-n}, we get the per-square-foot value

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buildings. In this model, without loss of generality, I do not distinguish among the type of buildings.

[11] For the sake of simplicity I assume that each floor has the same value. In truth rents are higher on higher floors, but here we can consider V_t to be the average rent per floor.

[12] In this paper I assume A is exogenous. The empirical implications of this are discussed below in section 5. In addition, I assume that the developer builds on the entire plot.

of land, which is based on the value of the building and the costs of building, as well as the size of the plot:

$$L^*_{t-n} = \frac{1}{4}\left(\frac{V_t^2 A_{t-n}^2}{C_{t-n}}\right). \tag{3}$$

Furthermore, I assume that the supply of plots that are available to developers to build on is a function of the value of the land at each period:

$$N_{t-n} = \gamma_0 \left(L_{t-n}\right)^{\gamma_1}. \tag{4}$$

Placing the right-hand side of equation (3) into the right-hand side of equation (4) gives an equation for the optimal number of skyscraper starts as a function of the costs and benefits of building:

$$N^*_{t-n} = \gamma_0 \left(\frac{V_t^2 A_{t-n}^2}{4C_{t-n}}\right)^{\gamma_1} \tag{5}$$

In terms of the market for building space, I assume, as in Wheaton (1999), that the demand for building space is given by a the following function:[13]

$$P_t = \alpha_0 D_t^{-\alpha_1} E_t^{\alpha_2},$$

where D_t is the quantity of space demanded, and E_t is the exogenously determined level of office employment.

Next, assume, similar to Wheaton (1999), that the short run supply (i.e., the current building stock at time t), S_t, is fixed so that the price is set to clear the market. This gives:

$$P_t = \alpha_0 S_t^{-\alpha_1} E_t^{\alpha_2}. \tag{6}$$

Since I do not have data for rent, equation (6) plays an important part in the analysis, since I will use building stock, employment and other demand variables to proxy for building rents.

For the reasons discussed in section 3.2, I assume that building values are determined by the discounted value of the net rental price at time $t-n$ (i.e.,

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[13] Without loss of generality, the model is simplified by having one variable that determines the quantity demanded and one that shifts demand. To reflect the particular characteristics of New York City, I include more variables in the empirical section below.

that developers use the current discount rate to determine the future value of a new building):

$$V_t = P_{t-n}/r_{t-n}, \tag{7}$$

where r_{t-n} is the current real discount rate (which also includes depreciation). Substituting the right-hand side of equation (6) for rent in equation (7), gives the building value as

$$V_t = \frac{\alpha_0 S_{t-n}^{-\alpha_1} E_{t-n}^{\alpha_2}}{r_{t-n}}. \tag{8}$$

Finally, substituting the right-hand side of equation (7) into equations (2) and (5) gives estimatable equations for the optimal building height and starts, respectively:

$$\begin{aligned} M_{t-n}^{*} &= \frac{\alpha_0}{2}\left(\frac{S_{t-n}^{-\alpha_1} E_{t-n}^{\alpha_2} A_{t-n}^{2}}{r_{t-n} C_{t-n}}\right) & (9) \\ N_{t-n}^{*} &= \gamma_0 \left(\frac{\alpha_0}{4}\right)^{\gamma_1} \left(\frac{\left(S_{t-n}^{-\alpha_1} E_{t-n}^{\alpha_2}\right)^2 A_{t-n}^{2}}{r_{t-n} C_{t-n}}\right)^{\gamma_1}. & (10) \end{aligned}$$

Since data exists only for the number of completions, I assume that the number of completions is equal to the number of starts $N_t = N_{t-n}$, and $M_t = M_{t-n}$.[14] Equations (9) and (10) are linear in log-log form.[15]

5 Empirical Results

Figure 1 shows the time series graphs over the period. The graph shows the cyclical nature of both the annual number of completions and the heights themselves, with average heights rising over the cycle.

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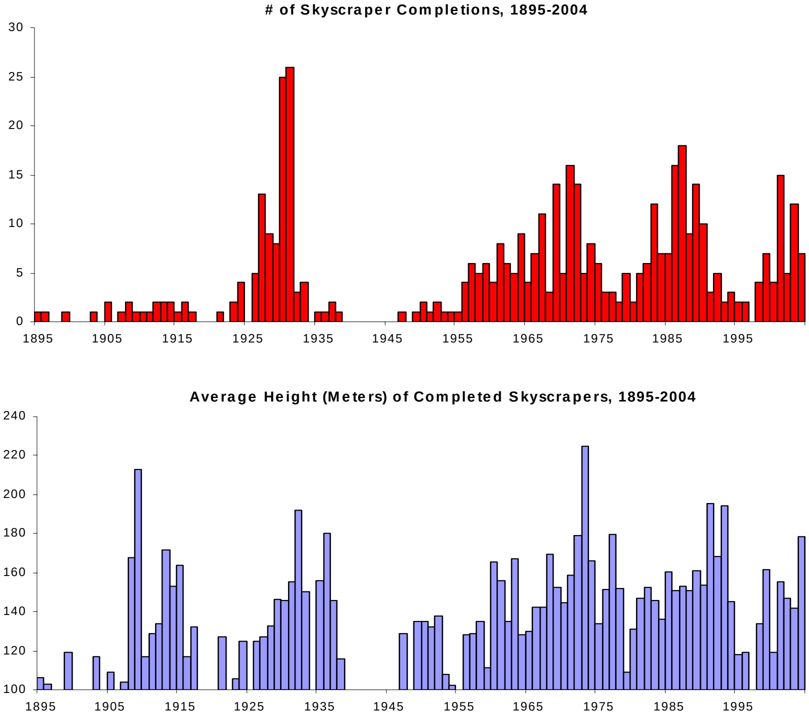
[14] Clearly, the number of completions can be less than the number of starts, but given the large costs of development, the irreversible nature of many construction-related decisions, and based on the fact that many building completions occur well into an economic downturn, this assumption appears to be valid.

[15] Since the real interest rate can be negative, it is left in levels in the regressions below.


# of Skyscraper Completions, 1895-2004

Average Height (Meters) of Completed Skyscrapers, 1895-2004

Figure 1: Annual time Series of number of skyscraper completions and their average heights, 1895-2004. Source: Emporis.com.

5.1 The Data

The model in section 4 generates equations for both the number of completions and the optimal height of these buildings as a function of the lags of several demand and supply variables. Similar to other works, I include office employment variables (see Wheaton (1999) and Kling and McCue (1987), for example), but, also include variables that relate directly to the New York City economy, and which have not been explored elsewhere.

In several cases, time series variables for New York City do not exist for the entire sample period of 1890 to 2004; in these instances, national variables are used. As will be demonstrated below, these variables are important determinants of skyscraper development in New York City. While some variables, like interest rates, inflation and access to credit, may show regional differences (see Bodenhorn (1995) for example), using national variables for

New York City is legitimate because of its importance for the national economy, as well as its centrality in national financial markets.

In addition, clearly there has been technological innovation and improvements in building materials and methods over the 20th century. However, I do not have a direct measure of technological change. Rather I use an index of real building material costs, which, at least implicitly, measures the effect of technological change.[16]

The Variables Table 2 presents the descriptive statistics for the data used in the time series regressions. In general, there is data for 115 years, 1890 to 2004. The dependent variables are observed from 1895 to 2004; additional years of data were acquired for the lags of the independent variables. For data about the buildings, I have the number of completions each year and the average of height of the completions.[17] The appendix gives details on how these variables were constructed. As a measure of the total building stock I use the net cumulative number of completed skyscrapers for each year. That is to say, the measure of total stock is the cumulative number of completions, with the number of destructions or demolitions removed in the year of the demolition or destruction. I also include the average area of the plots for the completed buildings.

{Table 2 here}

For office employment I use the proportion of total national employment that is in the Finance, Insurance and Real Estate industries (F.I.R.E./Emp.) (New York City employment data does not exist over the entire sample period). Building costs are measured via an index of real construction material costs (nominal building material cost index divided by the GDP deflator). To measure the access that developers have to capital, I use the annual growth rate of real estate loans provided by commercial banks; this is a measure of the willingness of banks to make loans, which is generally based on their belief about economic risk (see, for example, DePalma, 1986 and Hylton, R.

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[16] For example, the index of real construction costs used here peaked in 1979. Between 1979 and 2003, real constructions costs fell 15%. In 2003, the index was roughly the same value as it was in 1947.

[17] Note that, without loss of generality, I do not distinguish among uses for the buildings. Roughly 63% of the buildings are offices, the remaining 37% are residential, hotels or mixed use. Barr (2007b) investigates how use affects height.

D., 1990). For the real interest rate I use the rate on commercial paper rate minus the current inflation rate, as determined by the GDP deflator.

The New York City metropolitan area population is clearly an important determinant of the demand for building space. Over the course of the 20th century, the region has become more decentralized. While annual data exists for the New York City population, annual data for surrounding jurisdictions do not appear to exist (or are not accessible), as a result, decennial census data are used for the population of New York City and three counties in New York that supply a large fraction of workers and visitors: Nassau, Suffolk and Westchester.[18]

To measure the health of the New York economy, as well as the demand for building space, I use variables that relate to stock markets in New York: the annual average daily volume of stock trades on the New York Stock Exchange (NYSE) (a measure of the income available from stock trading), and the year-to-year change in the log of the Dow Jones Industrial Index, as a measure of the stock market returns.

For taxes, subsidies and zoning policy, I have four variables. First is the real estate tax rate (per $100 assessed value). Next, in terms of zoning, I include a dummy variable that takes on a value of one in years 1916 to 2004 to account for the presence of zoning regulations. In addition, I generate a "Westside" zoning dummy variable that takes on the value of one in the years 1982 to 1988. In these years, builders were given FAR bonuses to create the incentive to construct office space on the Westside of Manhattan's midtown business district. In terms of building subsidies, I use a dummy variable that takes on the value of one in the years 1977 to 1992, to measure the effect of the business subsidies offered in those years. Lastly, I include a "421-a" dummy variable that takes on a value of one in years 1971 to 1985 to reflect the relatively generous residential subsidies offered in this period.

Finally, the variable "economic volatility" was a derived variable designed to measure the volatility of building values. The variable is generated from eight variables that measure the health of the New York City economy.[19]

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[18] Note that New York City before 1898 was just Manhattan and Staten Island, but the population of the other boroughs are included from 1890.

[19] These variables are: (1) Nominal commercial paper rate, (2) the GDP Deflator Inflation rate, (3) the percent change in the Dow Jones Industrial Index, (4) the percent change in the New York Stock Exchange trading volume, (5) the New York City property tax rate, (6) the ratio of national F.I.R.E. employment to total employment, (7) the national unemployment rate, and (8) the growth in the equalized assessed values of land in

Each of the variables was normalized by subtracting its mean and dividing by the standard deviation (i.e., turned into a z-score). The four "bad" variables were then made negative, and all the z-scores were added together to create an economic activity index. The mean of this index is 0.0015 and the standard deviation is 3.11. Thus any value above zero indicates a robust New York City economy; anything below is a weak one. The volatility measure was derived by taking the standard deviation of the economic index for each year and the prior two years. Thus the volatility variable is a type of moving average, designed to measure the average variation in economic activity and hence building values for a three-year period.

In this study I assume that plot size is a randomly determined, exogenous variable. Builders, however, may seek out large plot sizes so they can build tall buildings since it is more efficient to build on larger plots. The problem of endogeneity, however, cannot be investigated further here due to the lack of instruments that are related to plot size but not height or completions. The average plot size variable is in the regression because the possible biases caused by its omission appear to be more relatively severe.

Investigation of the statistical properties of the average plot size time series and the effect of plot size on the other coefficients indicates that the assumption of exogeneity may not cause severe problems. First, the distribution of the log of average plot sizes appears to be log normal (the Jarque-Bera statistic is 3.89, with a p-value of 0.14), second the time series does not show autocorrelation across the whole sample, which would indicate that, in general, there is not a strong cyclical component to plot size; there does appear to be first order autocorrelation for subsamples, but this finding is not robust across subsamples of various years and year lengths.

5.2 Regression Results

As the model above demonstrates, the lags of many variables are important determinants of skyscrapers completions and heights. However, discovering the correct lag structure for each equation requires a bit of experimentation. As prior studies have discussed and as the data for this project indicate, building a skyscraper can take several years. In the vein of Wheaton (1999), starting with lag lengths of five years prior to completion, regression results were compared to other regressions with different lag lengths to see which

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Manhattan.

equations had the best overall fit, in terms of adjusted-R^2. In the end, lag lengths for the equations varied between one and four years.[20] In general, those variables that related to the demand for building space had shorter lag lengths than those that related to financing, which makes sense given that builders must first secure financing before beginning construction. The lag structure determined here most likely refers to the time lag between the receipt of a building permit and the time that the building starts receiving tenants. Clearly, the factors that go into initial planning and land acquisition can take much longer, but exploring these lengths is beyond the scope of the paper.

5.2.1 Number of Completions

Table 3 presents the regressions for the number of completions. The dependant variable is the log of one plus the number of completions.[21] In general these regressions show a good fit to the data, and the coefficients show the expected signs; this offers strong empirical validation of the market model presented in section 4. Table 3 presents two different models. Equation (1) looks at the determinants of completions with only the basic supply and demand variables (and the zoning dummy variable) to explore the role that just market factors play in skyscraper cycles and equation (2) is the "full" equation that also includes the effects of volatility, post-World War II policy changes and property tax rates.[22] The regressions had positive first-order serial correlation and heteroskedasticity; Newey-West standard errors were calculated.

Economic Variables In regard to market forces, over the course of the twentieth century, skyscraper building activity has been quite sensitive to both employment in Finance, Insurance, and Real Estate industries

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[20] Given that there exits no theoretical foundations on what is the correct or best lag structure for skyscrapers, I have employed a empirical approach to this question. While the method may appear *ad hoc*, imposing a fixed lag structure for all variables is, arguably, equally as *ad hoc*. Regression results with fixed lags are available upon request.

[21] For simplicity, the results of ordinary least squares rather than Poisson regressions are given. The results are quite similar.

[22] For brevity, I do not present the results of regressions that divide the sample into pre-1946 and post-1945 (i.e., after World War II) subsamples. These regressions are given in Barr (2007a). Though there are some differences in the coefficient estimates, a Chow test does not reveal a structural break between the two periods.

(F.I.R.E.), and the New York City regional population, with the number of completions being quite elastic with respect to these variables. Stock market growth and trading volume are also important determinants of completions, but have relatively inelastic effects. On the supply side, real building material costs significantly affect construction, with their effects being quite elastic. In terms of financing, interest rates appear to have modest negative effects on construction; this result concords with the early work of Long (1936) and more recently with McGough and Tsolacos (1999) and Wheaton (1987). Here, for example, a doubling in real interest rates from 5% to 10% would only decrease completions by less than 10%.

However, the access that developers have to real estate capital, as measured by the growth of real estate loans provided U.S. banks, appears to be a relatively stronger determinant of building construction.[23] Notice, too, that the variables that relate to project financing and the decision to build give the best fit when they are lagged three or four years before completion; those variables that relate to demand and construction costs have the best fit two years prior to completion. Finally, total volatility appears to be a negative determinant of completions, as would accord with the findings in the options literature, such as Holland, *et al.* (2002).

Policy Variables In addition, government policies have been important for both construction and height. The coefficient on the *zoning* variable (= 1 if after 1915, 0 otherwise) is negative, as would be predicted, but, interestingly, it is not statistically significant. The effect of zoning would be to presumably make buildings shorter, on average, and would therefore reduce the number of completions of very tall buildings. The coefficients show, however, this effect appears to be relatively large, decreasing completions by close to 18%. An F-test comparing separate zoning dummy variables for the 1916 and 1961 zoning regulations, respectively, did not show statically significant differences and thus only one dummy variable was included. The Westside zoning plan implemented in the mid-1980's in order to generate more office development appears to have been a very successful program, increasing the total number of completions by close to 60% during that period.

Furthermore, property tax subsidies, designed to increase office employment and housing, have had an important impact on skyscraper construc-

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[23] Note that the inclusion or exclusion of $\Delta \ln(R.E.\text{ Loans})$ from the equation does not materially affect the other coefficients, including the interest rate.

tion since the mid-1970's. The evidence indicates that housing subsidies (the "421-a" program) and business subsidies (the Industrial & Commercial Incentive Program) appear to have increased the number of skyscrapers by close to 55% more than would have been built otherwise during the periods in which both of them were simultaneously in effect. Lastly, the rate at which property is taxed appears to have reduced the number of completions, but the effect appears to be relatively inelastic (and is not statistically significant).

{Table 3 here}

5.2.2 Height

Table 4 presents the height equation results. Because for some years there were no completions of skyscrapers, there are no observations for those years. Equation (1) and (2) are the results of regressions where each observation is weighted by the square root of the proportion of completions in that year, which can be appropriate when dealing with variables are that are averages (and this also has the effect of removing the years for which no observations exist). Equations (3) and (4) are produced by ordinary least squares, but with the inclusion of a dummy variable for the years in which their were no completions.

A note about econometric estimation is in order. Here ordinary least squares estimation is preferred rather than Tobit estimation. The reason is that I am interested in estimating average height, conditional on at least one completion. Tobit estimation is appropriate when the data is censored; but since here the cutoff for a skyscraper is 100 meter, this does not technically create censored the data, but rather produces years where there are no observations. In the vein of Welch (1973), to control for the years in which there are no completions and to get a better estimate of the effect of the independent variables, I include a dummy variable that takes on one if there are no completions, zero otherwise.[24] Note that the presence of the dummy variable inflates the value of R^2; the reason it jumps from close to 0.5 to close to one is primarily because of the increased variation in the dependant

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[24] Tobit estimation results, however, are generally are similar to those from OLS estimation. In addition, a Heckman selection model was run, but the coefficient for the Mills ratio was found to be statistically insignificant, and the coefficient estimates were generally close to the results of the OLS model with the dummy variable. Results are available upon request.

variable; the R^2 of equations (1) and (2) offer better measures of explanatory power.

In terms of lag lengths we can see that the demand variables have the best fit with lags of one or two; while the "decision to supply" variables have optimal lags of two or three years. That the lag structure is a bit different for the height equation as compared to the completions equation is most likely due to the fact that height adjustments can be made during the course of the project, though not without some costs to the builders. As a result if, for example, building material costs are relatively high, for example, then the coefficient for that variable indicates, the decision to shorten the building can be made, on average, one year before completion.

Economic Variables Across equations we see that F.I.R.E. employment does not appear to be strongly related to height; this may be due to the fact that the variable is national rather than local, or that the marginal height decision is not directly affected by office employment *per se*. The New York City area population is perhaps the most important demand-side variable that affects the height decision.

On the supply side, height is negatively affected by costs, as would be expected. Similar to the completions equations, interest rates do not strongly determine height, though the variable is statistically significant. In addition, the coefficient that measures access to loans is positive, but not statistically significant at the 90% level.

Policy Variables The presence of zoning laws appears to have reduced building heights by a large percentage, close to 18%, as compared to the years before zoning regulations were in place. As discussed above zoning regulations were initially put into effect to limit shadows and density, rather than height *per se*. However, by limiting the amount of space a building can have, this places extra costs on builders; as a result, zoning has provided an economic incentive to limit height. In this vein, the "Westside" zoning coefficient is also negative, which is most likely because of the sunlight provisions in the zoning code amendment (though it is not statistically significant). The ICIP program appears to have provided an incentive for corporations to build taller; while the 421-a program appears not to have an effect on building height. Thus while tax abatements appear to have affected the decision to build they have mixed effects on the decision about how high to build.

Finally, in regard to the lag lengths for the independent variables, the two equations are different, with relatively longer lengths for the number of completions and shorter ones for the average heights. This is perhaps due to the fact that the decision about how high to "top off" a building can be delayed somewhat after the start of construction; if economic factors change then height can be adjusted.

{Table 4 here}

6 Predictions and Counter-factuals

As discussed above, the regressions based on the supply and demand model provide a good fit of the data, and are able to account for much of the skyscraper building activity from year to year. Figure 2 (top) provides the actual completions and the predicted completions (note that the results are presented in levels rather than logarithmic units). While the measured economic and policy factors capture a large fraction of the variation from year to year, the model is not able to account for a large number of completions that occur at the peak of the cycles. This is most notable in the 1920's, during the great building boom of that era. The reasons for the large deviations from the predictions are left for further research.

Using the model, though, we can generate counter-factual predictions, asking what would the market have looked liked, if, for example, certain government policies were never implemented. Figure 2 (bottom) shows predictions for completions from the regressions and predictions for completions with no zoning rules (or incentives) or tax abatement programs. We can see that in the pre-World War II years, zoning rules seem to have dampened completions only during the cycle peaks, while after the war, zoning seems to have had a more consistent dampening effect. Starting in the mid-1970's, however, when building subsidies were in effect, we see that the effect of these subsidies were quite strong. During the period 1978 to 1997, removing subsidies and zoning incentives substantially reduced predicted completions.

Figure 3 (top) shows the actual average heights and the predicted values. In general, the regression is able to account for the general trends in average heights from year to year. Figure 3 (bottom) compares the predicted heights from the regressions, Table 4, equation (4), to predicted heights without zoning or tax subsidies. We can see that the estimated effect of zoning has

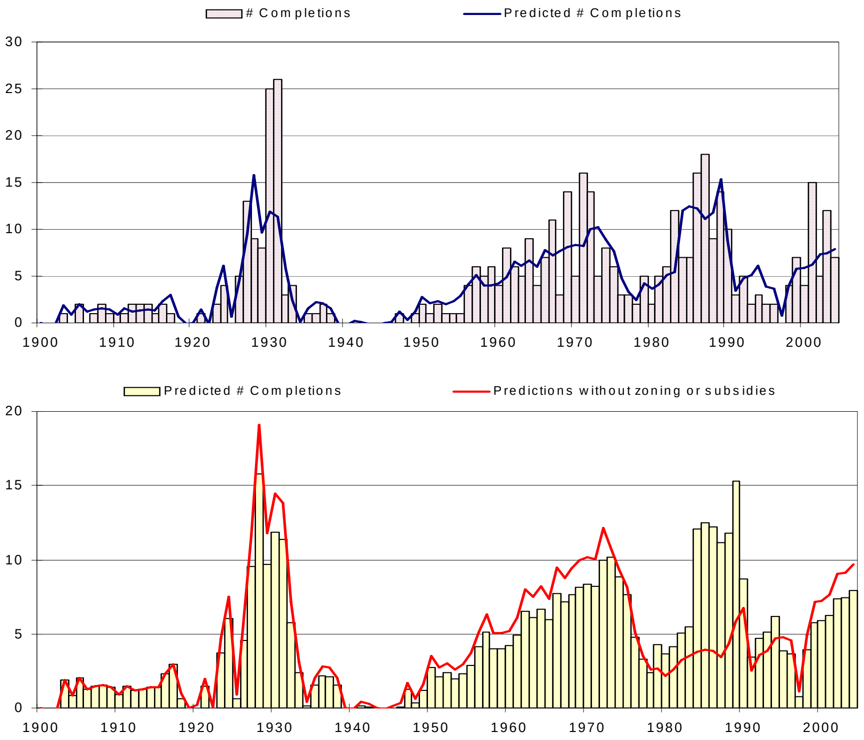

Figure 2: *Top Graph:* Actual and predicted number of completions, 1900-2004. *Bottom Graph:* Predicted number of completions and counter-factual predictions, 1900-2004.

been to reduce height by roughly twenty to thirty meters each year, which is roughly 4.5 to 6.5 fewer floors, on average. Clearly, this is just a rough estimate, since the effects of zoning are more complex than that which is studied here. During the late-1970's to the mid-1980's, without property tax subsidies, predicted average heights would have been lower.

7 Conclusion

This paper has presented an econometric analysis of the determinants of skyscraper construction and height in Manhattan from 1895 to 2004. I provide a simple model to generate optimal height and completions equations, which

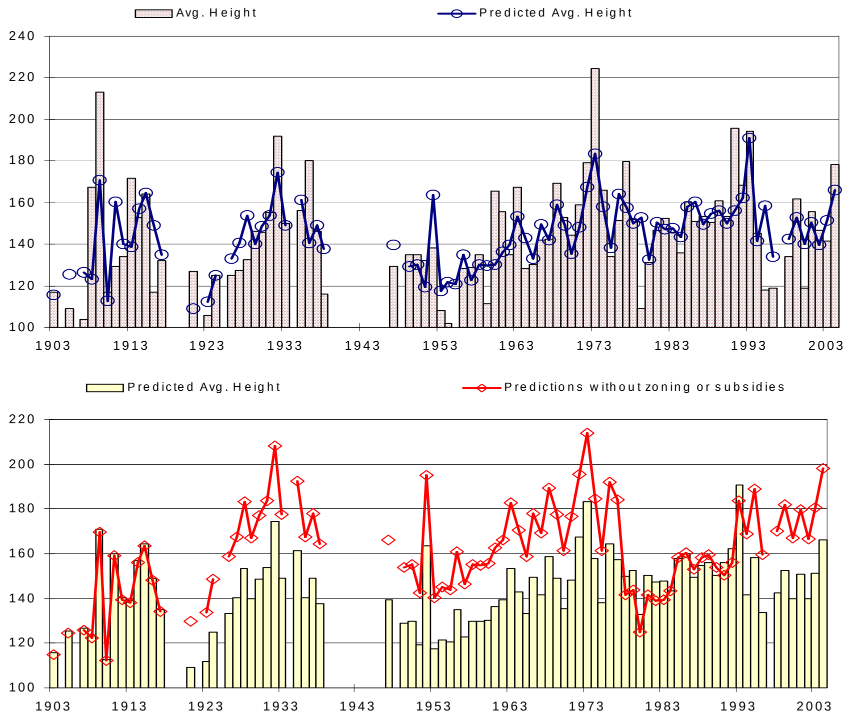

Figure 3: *Top Graph:* Actual and predicted average heights, 1903-2004. *Bottom Graph:* Predicted average heights and counter-factual predictions, 1903-2004.

are then empirically estimated. In general, skyscraper building patterns are related to the health of the city economy as well as policies that relate to land use and taxation.

The regression results show that the elasticity of completions with respect to the national employment in the Finance, Insurance and Real Estate (F.I.R.E.) sector is relatively elastic, as are building costs and regional population. Interest rates appear to play a relatively minor role in determining completions, while access to real estate loans is an important factor.

In addition, the regressions show the effect of specific government policies: property tax rates, zoning rules, and tax abatement programs. Abatements appear to have increased completions in the years that they were most generously given; the effect of these abatements are mixed for height, with a significant effect for corporate tax abatements, but not for housing tax abatements. Zoning rules in general have hindered both height and completions, as would be expected, though the zoning coefficients are not statistically significant across all specifications. Property tax rates also appear to negatively affect completions and height.

An investigation of the optimal lag structure shows that for completions variables that relate to building financing such as interest rates and access to capital have three or four year lags, while those variables that relate to the demand for building space and the construction of the building have optimal lags of two years prior to completion. For height, almost all variables have optimal lags of one or two years prior to completion.

The work here represents an initial study into the economic determinants of skyscraper completions and heights. There are many avenues for further research. For example, this study can be extended to include skyscraper building across cities in the U.S., by comparing, for example, Los Angeles, Chicago, Philadelphia and New York. While the work here investigates the economic and policy factors relevant for skyscrapers, future work needs to explore the psychological factors that influence skyscrapers, such as the desire to build the tallest building. In addition, a study of the role of technological change on skyscraper building patterns is sorely needed.

A Appendix: Data Sources and Preparation

-*Skyscraper Height, Year of Completions and Current Status (extant or not), and Net Total Stock.* The primary source is Emporis.com, which provides information on the height, year of completion and status (demolished or not). As of January 2005, the website listed 472 buildings in Manhattan that are 100 meters or taller; these buildings could be of any type, including for office, apartment, and mixed uses.[25] I aggregated the data to generate the number of completions per year, the average height of those completions for each year, and the total net cumulative number of completions. The year of demolition or destruction (if applicable) was found from articles from the historical New York Times (proquest).

-*Average plot size:* Data on each building's plot size comes from the NYC Map Portal (http://gis.nyc.gov/doitt/mp/Portal.do), Ballard (1978); http://www.mrofficespace.com/; NYC Dept. of Buildings Building Information System,

(http://a810-bisweb.nyc.gov/bisweb/bsqpm01.jsp).

-*Real Construction Cost Index.* Index of construction material costs: 1947-2004: Bureau of Labor Statistics Series Id: WPUSOP2200 "Materials and Components for Construction" (1982=100). 1890-1947: Table E46 "Building Materials." *Historical Statistics* (1926=100). To join the two series, the earlier series was multiplied by 0.12521, which is the ratio of the new series index to the old index in 1947. The Real index was create by dividing the construction cost index by the GDP Deflator for each year.

-*Inflation*, 1890-2004: GDP Deflator, EH.net (2000=100)

-*Value of Real Estate Loans*: 1896-1970: Table X591, "Real Estate Loans for Commercial Banks." *Historical Statistics.* 1971-2004: FDIC.gov Table CB12, "Real Estate Loans FDIC-Insured Commercial Banks." The two series were combined without any adjustments. For 1890-1895: Values are generated by forecasting backwards based on an $AR(3)$ regression of the percent change in real estate loans from one year to the next.

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[25] A few caveats are in order. I have every reason to believe the list is very close to complete. Since this is the only list of its kind there is no ability to cross check it. However, given the data collection for this paper and for Barr (2007b), and due to the apparent thoroughness of Emporis' data collection process, the list appears to be quite close to complete, if not 100% so.

Secondly, clearly there can be some debate about what constitute the year of completion; and in this regard there is some discrepancies with other sources, such as New York City's web-based G.I.S. database. However, it was felt best to use the Emporis' year for the sake of consistency and because Emporis is a for-profit firm and, presumably, has a vested interest in culling the most accurate data possible.

-*Finance, Insurance and Real Estate Employment (F.I.R.E)/Total Employment:* 1900-1970: F.I.R.E. data from Table D137, *Historical Statistics.* Total (non farm) Employment: Table D127, *Historical Statistics.* 1971-2004: F.I.R.E. data from BLS.gov Series Id: CEU5500000001 "Financial Activities." Total nonfarm employment 1971-2004 from BLS.gov Series Id:CEU0000000001. The earlier and later employment tables were joined by regressing overlapping years that were available from both sources of the new employment number on the old employment numbers and then correcting the new number using the OLS equation; this process was also done with the F.I.R.E. data as well. 1890-1899: For both the F.I.R.E. and total employment, values were extrapolated backwards using the growth rates from the decade 1900 to 1909, which was 4.1% for F.I.R.E. and 3.1% for employment.

-*Real Interest Rate (nominal rate minus inflation):* Nominal interest rate: 1890-1970: Table X445 "Prime Commercial Paper 4-6 months." *Historical Statistics.* 1971-1997 http://www.federalreserve.gov, 1998-2004: 6 month CD rate. 6 month CD rate was adjusted to a CP rate by regressing 34 years of overlapping data of the CP rate on the CD rate and then using the predicted values for the CP rate for 1997-2004. Inflation comes from the percentage change in the GDP deflator.

-*Average Daily NYSE Traded Stock Volume:* http://www.nyse.com/

-*Dow Jones Industrial Index (closing value on last day of year):* 1896-1932: Pierce (1996); 1933 - 2004 from Yahoo.com. 1890-1895: Generated "backwards" from predicted values based on a regression of the DJI on NYSE Volume, the year, and total nonfarm employment, from 1896-1925.

-*NYC Property Tax Rates (per $100 total assessed value):* 1890-1975: Various volumes of the *NYC Tax Commission Reports.* 1976-2004: NYC Dept. of Finance website. Note that in 1983 tax rates became different for different types of property usages. The rates used here are the commercial property.

-*Annual NYC Population*: 1890-1959: Various annual reports of the NYC Health Department. 1960-2004: NYC Department of Health website:

http://home2.nyc.gov/html/doh/downloads/pdf/vs/2005sum.pdf

-*Population NYC, Nassau, Suffolk, Westchester:* 1890-2004: Decennial Census on U.S. Population volumes. Annual data is generated by estimating the annual population via the formula $pop_{i,t} = pop_{i,t-1}e^{\beta_i}$, where i is the census year, i.e., $i \in \{1890, 1900, ..., 2000\}$, t is the year, and β_i is solved from the formula, $pop_i = pop_{i-1}e^{10*\beta_i}$. For the years 2001 to 2004, the same growth rate from the 1990's is used.

-*Equalized Assessed Land Value Manhattan:* 1890-1975: Various volumes of

NYC Tax Commission Reports. 1975-2004 Real Estate Board of NY. Equalization Rates: 1890-1955: Various volumes of *NYC Tax Commission Reports.* 1955-2004: NY State Office of Real Property Services. *Equalization Rate:* 1890-1955: Various reports *NYC Tax Commission Reports.* 1955-2004: NY State Office of Real Property Services.

-*U.S. Unemployment Rate:* 1890 to 1970 Table D85 *Historical Statistics*; 1971-2004: Bls.gov Table LNU04000000.

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Variable	Mean	Std. Dev.	Min.	Max.	Obs.
Manhattan Skyscraper Variables					
Manhattan Skyscraper Completions	4.30	5.18	0.00	26.00	110
Avg. Height of Completions (meters)	143.36	25.26	100.0	224.60	87
Avg. Plot Size (sq. feet)	48,828	47,236	5,198	342,937	87
Net Total Cumulative # of Skyscrapers	169.60	142.52	1.00	463.00	110
National Economic Variables					
Real Construction Costs Index	1.28	0.267	0.862	1.70	115
Inflation, GDP Deflator (%)	2.46	4.47	-17.30	18.93	114
Δ *ln*(Value of Real Estate Loans)	0.08	0.073	-0.165	0.352	114
F.I.R.E /Total Employment	0.044	0.015	0.018	0.066	115
Economic Volatility	2.47	1.35	0.437	6.52	111
Real Interest Rate (%)	2.29	4.73	-13.86	23.92	114
Unemployment (%)	6.87	4.73	1.20	24.9	115
NYC Economic Variables					
Avg. daily NYSE Traded Stock Volume (M)	103.3	290.6	0.11	1456.7	115
Δ *ln*(Dow Jones Industrial Index)	0.04	0.214	-0.740	0.623	114
NYC Property Tax Rate (per $100 AV)	4.70	3.16	1.41	11.43	115
Δ *ln*(Equalized Land Value Manhattan)	0.038	0.075	-0.184	0.330	114
NYC Population (M)	6.49	1.83	1.61	8.13	115
Pop.: NYC, Nassau, Suffolk, Westchester (M)	8.43	2.79	2.74	11.90	115
NYC Dummy Variables					
Zoning Law Dummy (1916-2004)	0.774				115
"Westside" Zoning (1982-1988)	0.061				115
Indstl. & Comm. Incentive Prgrm. (1977-1992)	0.139				115
"421-a" (1971-1985)	0.130				115

Table 2: Annual time series descriptive statistics, 1890 to 2004. See Appendix for sources.

Dep. Var.: $ln(1 + Number\,Completions)$		
	(1)	(2)
$ln(F.I.R.E/Emp)_{t-2}$	2.37 (3.58)***	2.70 (4.23)***
$ln(total\,stock)_{t-2}$	-1.54 (5.72)***	-2.18 (8.17)***
$ln(construction\ costs)_{t-2}$	-1.72 (2.46)**	-2.12 (3.64)***
$ln(NYSE\ volume)_{t-2}$	0.129 (3.25)***	0.138 (2.16)**
$ln(NYC\ area\,pop.)_{t-2}$	5.82 (4.67)***	7.94 (7.42)***
$zoning_{t-2}$	-0.486 (1.49)	-0.182 (0.76)
$\Delta\ln(R.E.\,Loans)_{t-3}$	1.70 (2.34)**	0.983 (2.27)**
$\Delta\ln(DJI)_{t-3}$	0.534 (2.30)**	0.472 (2.41)**
$real\ interest\ rate_{t-4}$	0.001 (0.07)	-0.016 (1.77)*
$volatility\ index_{t-2}$		-0.151 (3.59)***
$westside\ zoning_{t-2}$		0.641 (2.60)**
$ICIP_{t-2}$		0.414 (1.95)*
$421a_{t-2}$		0.131 (0.8)
$ln(tax\ rate)_{t-2}$		-0.181 (0.51)
$ln\,(avg.\,plot\ size)_t$	0.089 (7.46)***	0.081 (6.04)***
$Constant$	-79.1 (4.22)***	-108.6 (6.77)***
$Observations$	110	107
R^2	0.77	0.85
$\bar{R}^2$	0.75	0.82
$Durbin-Watson$	1.35	1.97

Table 3: Absolute value of Newey-West t-statistics in parentheses. *significant at 10%; **significant at 5%; ***significant at 1%.

$Dep.Var : ln(avg.\ height)$				
	$(1)^{\%}$	(2)%	(3)	(4)
$ln(F.I.R.E/Emp.)_{t-2}$	0.254 (0.97)	−0.286 (0.88)	0.189 (1.19)	0.041 (0.24)
$ln(total\ stock)_{t-2}$	0.042 (0.54)	−0.067 (0.73)	−0.004 (0.06)	−0.103 (1.55)
$ln(construction\ costs)_{t-1}$	−0.520 $(4.02)^{***}$	−0.826 $(3.78)^{**}$	−0.454 $(3.38)^{***}$	−0.649 $(3.65)^{***}$
$ln(NYSE\ vol.)_{t-2}$	0.00 (0.01)	0.05 $(1.79)^{*}$	0.019 (1.6)	0.033 (1.49)
$ln(NYC\ area\ pop.)_{t-1}$	0.251 (0.9)	1.15 $(3.49)^{***}$	0.177 (0.65)	0.782 $(2.52)^{**}$
$zoning_{t-2}$	−0.351 $(2.03)^{**}$	−0.215 (1.03)	−0.199 $(2.27)^{**}$	−0.183 (1.6)
$\Delta\ln(R.E.\ Loans)_{t-3}$	0.308 (1.50)	0.196 (0.92)	0.315 $(1.66)^{*}$	0.165 (0.84)
$\Delta ln\,(DJI)_{t-2}$	0.052 (0.86)	0.095 $(1.64)^{*}$	−0.015 (0.27)	−0.008 (0.12)
$real\ interest\ rate_{t-2}$	0.001 (0.28)	0.001 (0.24)	−0.005 $(1.79)^{*}$	−0.005 $(1.71)^{*}$
$ln(tax\ rate)_{t-2}$		−0.147 (1.02)		−0.060 (0.56)
$volatility\,index_{t-2}$		0.007 (0.60)		0.001 (0.12)
$westside\,zoning_{t-2}$		−0.077 (1.59)		−0.061 (1.08)
$ICIP_{t-1}$		0.264 $(3.82)^{***}$		0.214 $(2.85)^{***}$
$421a_{t-1}$		0.019 (0.64)		0.021 (0.44)
$ln\,(avg.\ plot\ size)_t$	0.122 $(3.96)^{***}$	0.165 $(5.08)^{***}$	0.120 $(5.58)^{***}$	0.140 $(6.57)^{***}$
$at\ least\ one\ completion_t$			3.65 $(16.17)^{***}$	3.42 $(15.02)^{***}$
$Constant$	0.665 (0.18)	−16.0 $(3.18)^{***}$	−2.21 (0.54)	−11.9 $(2.54)^{**}$
$Observations$	87	86	110	109
R^2	0.46	0.56	0.997	0.997
$\bar{R}^2$	0.39	0.47	0.996	0.997
$Durbin-Watson$	1.37	1.67	1.48	1.72

Table 4: Absolute value of Newey-West t-statistics in parentheses.*significant at 10%; **significant at 5%; ***significant at 1%. $^{\%}$Variables in each year weighted by square root of number of completions; year with no completions for dep. var. were dropped.