Skyscrapers and Skylines: New York and Chicago, 1885-2007

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Abstract

This paper compares and contrasts the determinants of the market for skyscrapers in Chicago and New York from 1885 to 2007, using annual time series data. I estimate the factors that determine both the number of skyscraper completions and the height of the tallest building completed each year in the two cities. I find that each city responds differently to the same economic fundamentals. Also, regressions test for and find the presence of strategic interaction across the two cities. I also estimate the effects of zoning regulations on height. Compared to New York, Chicago's zoning policies significantly reduced the height of its skyline.

key words: New York, Chicago, skyscrapers, building height.

JEL Classification: R1, R33, N6, N9

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> *The character and quality of any city can be told from a great distance by its skyline, but these buildings do more than advertize a city. They show the faith of many in its destiny, and they create a like faith in others (Shultz and Simmons, 1956, p.12).*

1 Introduction

Since the mid-1880s, the skyscraper has been an important part of the American historical and economic landscape. As Ford (1992) writes, "For nearly eight decades the skyscraper was largely an American phenomenon and seemed to symbolize the energy, enthusiasm and optimism that characterized the United States in the late nineteenth and early twentieth centuries" (p. 180). Yet despite their importance in American history, surprisingly little work has been done in economics on investigating the causes and consequences of building height.

As historians, architects and journalists have discussed, the skyscraper is a unique good because of the grandness of its technological sophistication, its symbolic importance (as an aesthetic element, and for advertising and "positional" purposes) and because collectively skyscrapers generate an entirely new entity–the skyline.[1] This skyline serves to advertise the economic might of a city, beyond the power of any one building contained within it. One only has to fly over New York or Chicago to feel its dramatic impact.[2]

Since the early days of the skyscrapers invention, New York and Chicago have been two of the world's premier skyscraper cities. By 1929, New York and Chicago contained 68% of the nation's buildings that were 20 stories or taller (Weiss, 1992). Each city was a testbed for innovation and each used height as a way to house rapidly growing populations and to advertise its growing wealth. Currently, New York and Chicago hold 56.6% of the nation's buildings that are 239 meters (785 feet) or taller. Of the ten

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[1] Their importance and uniqueness is witnessed by the fact that there is a large market for products about skyscrapers and skylines, such as coffee table books, souvenirs, pictures, television shows, museum exhibitions, etc. One would assume that the revenues for skyscraper-related merchandise is in the billions of dollars.

[2] A study by Heath et al. (2000) demonstrates that the nature of a skyline's complexity and articulation can affect emotional well-being. They find, "The strongest influence on preference, arousal, and pleasure was the degree of [skyline] silhouette complexity, with higher silhouette complexity associated with higher levels of...preference and higher arousal and pleasure" (pps. 541-2).

current tallest buildings in the U.S., four are in Chicago and four are in New York (six would be in New York, if the Twin Towers were included) (http://www.emporis.com, 2010).

By the second half of the 19th century, both cities were participating in a national network of trade and capital flows (Rosenbloom, 1996). Given the ability of labor and capital to move to locations where the returns are greatest (Glaeser and Gotlieb, 2009), we would expect that this would lead to some degree of competition between these two leading cities. New York and Chicago were originally linked by the Erie Canal and by Eastern capitalists investing in the Chicago region.[3] As such the two cities directly engaged in trade, which fostered economic growth as well as economic rivalry. Skyscraper height is perhaps the most famous aspect of this competition.

The literature on regional growth, however, has generally been silent on strategic interaction. Davis and Weinstein (2002) summarize the three main theories in regard to economic geography: increasing returns, random growth (Gibrat's Law) and locational fundamentals. None of these areas include any direct measures of inter-regional competition per se. That is to say, this body of literature discusses how a region's growth can be accounted for by the combination of economies of scale and first mover advantage (Krugman 1991), by the presence of specific agglomeration benefits that accrue from clustering, such as from knowledge spillovers (Glaeser, 1999) or by some fundamental locational benefit, such as a central port or the confluence of freshwater bodies (Ellison and Glaeser, 1999).

More recently regional science studies have investigated "the formation of policies designed to promote local economic development, often explicitly, but certainly implicitly, in competition with other territories" (Cheshire and Gordon, 1998, p. 321-322). In this vein, governments specifically design tax policies, infrastructure investments or land use regulations to lure business activity away from one region to another. But these types of direct government interventions generally did not exist in the 19th and early 20th centuries. Today these policies are often limited to specific projects, such as sports arenas (Siegfried and Zimbalist, 2000) or tax abatements for specific corporations (Glaeser, 2001).

With the rise of big business and the centralization of corporate head-

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[3] A Cronen (1991) demonstrates Chicago was made possible by three important factors: (1) a vast hinterland of productive agricultural output and natural resources, (2) an international market for its output, mostly funneled through New York, and (3) the collective *expectation* that Chicago would be the regional hub linking hinterlands to eastern markets.

quarters in places such as New York and Chicago, real estate developers naturally compete against each other to lure businesses to their new buildings.[4] Early technological innovations, such as steel-cage construction and elevators, permitted the first generation of real estate developer competition with regard to skyscrapers.[5] Builders incorporated these new technologies to improve the quality of tenant life, reduce susceptibility to fire, and to house more space on a given piece of land.

More activity on a given plot allows for increased agglomeration benefits, and the chance to presumably lure businesses away from other regions.[6] For the tenants, new buildings also provide advertising and status benefits (such as through naming rights or through the status of being in a well-known building, built by a famous architect, for example). In short, developer competition has meant better buildings and increased competition to improve a city's relative position.

A good example of this is provided in a recent *Wall Street Journal* (2010) article, which writes,

> [A]s the world economy rebounds and competition heats up among financial centers, the availability for modern office space will play a part in determining winners and losers.
>
> "I think it's dangerous, because people need facilitates, and there is no place to go," says New York's Larry Silverstein, the developer of three office towers at the World Trade Center....Mr. Silverstein notes that 60% of the buildings in New York City are more than 60 years old. "For the most part, I think it serves as a depressant not to have first-class facilities available at the time [tenants] want to move to them," he says (p. 2).

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[4] As Strauss-Kahn and Vives (2009) show, the New York and Chicago regions are still leading centers for headquarters. As of 1996, New York and Chicago ranked first and third in that nation in terms of number of headquarters, respectively.

[5] Over the 20th century, builders have introduced such things as air conditioning, fluorescent lighting, better wind bracing, and computerized elevator systems. More recently builders are "going green" to reduce the use of resources (Pogrebin, 2006). To the best of my knowledge, however, no work has aimed to measure the rate or value of technological change in regard to skyscrapers.

[6] The highrise office building, in many respects, promotes the same types of agglomeration benefits as a city as a whole, only vertically. For example, tenants can share the burden of fixed costs and maintenance; they have reduced communication and transportation costs; clustering of similar type firms can lower search labor search costs and increase product demand and increase knowledge spillovers, etc.

Historically, skyscrapers, therefore, embody two types of competition: regional competition for employment and industry growth, and competition among builders themselves to have a place within a "height hierarchy." That is, skyscrapers can be thought of as "positional goods" (Frank, 1985) due to psychological feelings of local pride and the apparent innate desire of humans to engage in conspicuous consumption (or investment) to achieve social status within a social hierarchy (such as has been modeled in Helsley and Strange, 2008).

Competition, however, can lead to two possible effects, depending on the nature of this competition. On one hand, height in two cities might be strategic complements (Barr, 2010; forthcoming). If developers use their buildings to place themselves in a favorable position in the height market or urban hierarchy then builders will positively respond to the decisions of builders in the other city–thus creating a positively sloped reaction function.

On the other hand, increasing the amount of building space will have the affect of reducing the price of space and thus, in the vein of a standard Cournot model, the best response function will have a negative slope. This work here aims to test which effects might be present.

Despite the importance of New York and Chicago in regard to both skyscrapers and regional competition, little work in economics has directly investigated these issues. This work aims to fill this gap by comparing and contrasting the factors that have determined skyscraper frequency and heights in New York and Chicago since 1885. By investigating these two cities, we can get a sense of the degree to which skyscraper activity is location-specific or not, and the degree to which these two city's skylines are a result of strategic interaction.

This work investigates the following questions:

- What are the most important drivers of the skyline itself, and is there evidence that the skyline has been shaped by inter-regional competition between New York and Chicago?
- Which of the two cities is more "prolific," controlling for the underlying economic environments and building regulations? What does the productivity suggest either about tastes or more generally the demand for building height across cities?[7]

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[7] One way to infer tastes for height is to look at the degree to which cities have placed height restrictions on buildings. For example (discussed in more detail below), Chicago

- Lastly we can compare how the different height regulations have impacted the two cities. Chicago, unlike New York, placed outright height caps on their buildings. Did these caps significantly reduce the size and scope of Chicago's skyline vis a vis New York?

Clearly, the term "skyscraper" can have different meanings depending on the context. For example, a skyscraper can be defined based on its relative height compared with nearby buildings, or it can be defined based on technological considerations (i.e., if built with a load-bearing steel cage and with an elevator). However, to simplify the analysis in this paper, a skyscraper here is defined based on two perspectives. The first is based on a fixed height (for New York I use 90 meters as the cut off; for Chicago I look at 90 meter and 80 meter cutoffs).[8] Second, I also look at the tallest building completed in each city each year since 1885. Since builders often use their skyscrapers for advertising (be it their corporations or their own egos), if there exists a competitive effect across cities, then presumably it would most likely appear at the extreme height level.

By looking at the count of skyscrapers and investigating whether the count in one city is affected by the count in the other city, we can test for whether buildings do in fact use their buildings as strategic elements to attract businesses to the city and to improve urban growth. By looking at the height of the tallest building we can also test for the degree to which the two cities have engaged in ego-based competition (controlling for the other factors that drive height).

Based on the time series data for New York and Chicago from 1885 to 2007, here is a brief summary of the findings. In regard to the determinants of the respective skylines, I find that in general economic and policy variables explain a large fraction of the variation in the height decisions of the

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throughout the 19th and early 20th centuries capped height at various levels. Washington DC has prohibited buildings from being taller than the Capitol. Until 1986 there was an unwritten rule that no building in Philadelphia could be taller than the statue of William Penn standing a top City Hall. See Weiss (1992) and Comey (1912) for a list of cities that had height restrictions.

[8] 80 meters is used as a cutoff to increase the number of years with positive observations. Because of building height restrictions in Chicago there are several years without any "skyscraper" completions. Regressions using a 90 meter cutoff were also run (results presented below). Using the log of one plus the number completions as the dependent variable, I do not find large differences in coefficient estimates if I use an 80 or 90 meter cutoff. Unless otherwise noted for the remainder of this paper a "skyscraper" in Chicago will assumed to be 80 meters (about 23 floors, on average) or taller.

two cities. However, New York's responses to supply and demand variables seem to be more elastic than Chicago's. Chow tests also show significant differences in the coefficients. I also find evidence for interaction effects across cities. That is to say, the evidence suggests that New York height decisions have impacted Chicago's height decisions and vice versa, controlling for other determinants of the skyline. For all four variables (New York's height and count, and Chicago's height and count), I find evidence of both strategic complementarity and substitutability across cities.

In regard to height restrictions, Chicago's decision to cap height has had an impact on the height of its skyline, compared to New York City and compared to Chicago's history without building height restrictions. However, controlling for both building height restrictions and economic factors, the evidence suggests that Chicago is actually the more prolific of the two cities.

The rest of this paper proceeds as follows. The next section reviews the relevant literature. Following that, section 3 gives a brief review of skyscraper economics. Then section 4 discusses the history of interactions between the two cities, as well as their respective policies on building height. Following that, section 5 gives estimation results for the determinants of skyscrapers in the two cities. Finally section 6 offers concluding remarks. An appendix provides additional information on the sources of the data.

2 Relevant Literature

2.1 Chicago

To the best of my knowledge there is no work within economics exploring the economic determinants of building height in Chicago, nor is there any comparing New York to Chicago. There is, of course, work on land values, land use, and the Chicago office market, all of which are related to skyscraper height. The classic work on land values in Chicago is that of Hoyt (1933), who explores the interaction between the business cycle, population growth and land values in Chicago from 1830 to 1930. He finds that land values had wide swings, with roughly 16 year cycles on average. McMillen (1996) follows up on this work by exploring Chicago land values from 1830 to 1990. He finds that, among other things, the monocentric model no longer applies. Moses and Williamson (1967) explore the determinants of industrial decentralization in the region.

In regard to the Chicago office market Mills (1990) performs a hedonic regression of asking rents for 543 office buildings in the Chicago area. He estimates the value of several amenity and locational factors to determine the value of these rents. He does not, however, estimate the value of additional height or of being in a tall building. In a related study, Colwell, et al. (1996) perform a hedonic study of the asking price of 427 office buildings in the Chicago metropolitan area; while they do find a height premium, the average building height in their sample only has three floors. Abadie and Dermisi (2008) find that vacancy rates around Chicago's landmark buildings increased due to the terrorist attacks of September 11, 2001.

In regard to zoning, to the best of my knowledge, there is no work on how building height regulations have either directly or indirectly affected building height across cities. McDonald and McMillen (1998) study how Chicago's 1923 ordnance affected land values, by restricting some blocks to having only residential buildings. They find that this law introduced inefficiencies into the land market, since the evidence suggests that residents would have preferred at least some commercial activity mixed with housing.[9]

2.2 New York and Skyscrapers

Perhaps the most cited work on the economics of skyscrapers in New York is that of Clark and Kingston (1930). Their objective was to estimate the economic height of a "typical" office tower in Manhattan as of 1929. They conclude that a 63 story building would provide the highest return using land prices, construction costs and rent data from 1929.

More recently a game-theoretic model of building height has been provided by Helsley and Strange (2008). They observe that record-breaking height is often "clumpy," with records often broken in rapid succession. In addition, they observe that across cities, the tallest building is often much taller than the surrounding buildings. These facts suggest the developers may engage in height races, such as that observed between 40 Wall Street and the Chrysler building in 1929. Their model shows how strategic interaction can result in the construction of buildings that are economically "too tall," in the sense that the height contest can dissipate profits from construction.

These two works, however, only, investigate skyscraper height for only one

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[9] Papers such as and Bertaud and Brueckner (2005), and Glaeser, et al. (2005), investigate the effect of land use regulations on the construction and cost of housing.

or two builders. They do not analyze the broader market for height. In this vein Barr (2010) looks at the market for height in Manhattan over the period 1895 to 2004 by investigating the time series of the number of skyscraper completions and the average height of these completions. The paper finds that 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, there has been no fundamental change in skyscraper building patterns. Height is primarily determined by factors related to both the New York City and national economies, regulations on land usage, and taxation. Importantly, there has been no upward trend in average heights over the last century; this provides evidence that, within Manhattan, ego-driven height does not appear to be a systematic component of the skyscraper market.

Barr (forthcoming) is the only work that looks at the determinants of building height, *at the building level*, in Manhattan over the 20th century. The aim of this work is to test for the possibility of localized strategic interaction (i.e. to see if spacial interaction within a city varies at the block level) and to test for the effects of building height regulations. The evidence suggests that height competition is localized across both time and space, and only exists when the opportunity cost of competition is relatively low. On average, during periods of height competition, we see builders adding about 5 or 6 extra floors to stand out among the surrounding buildings.

Since New York never directly limited building height, it's important to see how its zoning regulations (discussed below) may have altered the skyline. The finding in Barr (2010) is that zoning rules in place between 1916 and 1960 in midtown Manhattan, for example, reduced building height by 115 feet (about 9.5 floors) on average. Since 1961, if builders are able to purchase air rights and they take advantage of amenity bonuses, average height has only dropped by about 1 floor as compared to the years with no zoning. The work here explores how zoning has affected the tallest buildings completed each year.

3 Skyscraper Economics

In general, building height is caused by expensive land values; a skyscraper is "a machine that makes the land pay" (Gilbert, 1900, p. 643). If land represents a large fixed costs, then as land values rise, the range of height over which average total costs are falling will be increasing. That is to say, as land values rise there will be greater economies of scale for building height.[10]

However, land values for a particular plot emerge from the discounted residual profits from the use and value of surrounding land. Within central business districts, these profits result from the agglomeration benefits that come from labor clustering for office workers and the development of large hub-and-spoke transportation systems, which move vast numbers of workers into the center each day.

Early office buildings were built with load-bearing masonry walls, which was a significant constraint on height. As a building grew taller the bottom floor walls had to be proportionally thicker to hold the load. At some point, the walls would be so thick that the lower floors would be unrentable, thus making additional height unprofitable. In addition, without elevators (and safety breaks) people were unwilling to climb more than five or six flights of stairs.[11] By around the early 1880s, the technological capabilities to build tall had been discovered. Presumably, once the technologies for skyscrapers were well-known, this put even more pressure on land values since builders knew they were not technologically limited; thus creating positive feedback between building heights and land values.

Land values, however, are not the only factor driving height. Skyscrapers can act as symbols of human expression. The architecture of the buildings express the aesthetic tastes of their designers (and perhaps the public at large). Corporations may use height to advertise their names or economic strength; builders can use height as an expression of "conspicuous production" or a form of ego-based competition (Helsley and Strange, 2008). Furthermore builders can use height as an expression of civic pride and "urban boosterism" (Cronon, 1991).

The huge influx of labor and capital into cities in general, and New York and Chicago in particular during the 19th century, demonstrates the mobility of inputs. Presumably, firms have choices about were to locate and they

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[10] Say total costs to skyscraper development are given by $TC = L + \beta H^2$, where L is total land costs (say of given plot size) and H is building height. Then the H that minimizes average total costs is given by $H^* = \sqrt{L/\beta}$, so that, cet. par., greater land costs will promote the incentive to build taller.

[11] Another important technological consideration was that of foundation preparation. Tall buildings have to be stabilized below ground to prevent settling. Chicago and New York generally faced differing subsoil conditions and thus the first generation of engineers devised differing solutions to foundation preparation. A detailed discussion of this is beyond the scope of this paper. See Barr et al. (2010) for a discussion for New York. See Peck (1948) for Chicago.

would prefer to go where office space is available and where they can find labor. As such, skyscraper height can represent a form of urban competition, as it provides both needed office space and signals the strength of a city, which generates a "faith" in its future success.[12]

As such it's natural to ask to what extent there are interactions among cities in regard to skyscrapers. As discussed below, since 1885 New York and Chicago have ostensibly been involved in various height competitions. The popular literature has focused on the most extreme cases, but to what extent is there evidence that some form of competition is a systematic part of the height market in these two cities?

Barr (forthcoming; 2010) shows that height moves in cycles. As economic activity increases, there is an increased need for space. This, in turn, bids up land values, which increases the number of skyscrapers. Each year therefore there will be a distribution of skyscraper heights. In years where there are more skyscrapers, one would expect that the probability of observing taller buildings would increase.[13] The likelihood of a larger maximum value would presumably be a function of the increased likelihood of a builder having a favorable location or the fact that some builder would come along who has a greater desire to add extra floors either for advertising, ego-driven or urban-boosterism effects, since presumably, after some point the costs of additional height may not pay for themselves with additional rents. That is to say, as the economic conditions favor tall building, the opportunity cost of adding extra height for non-pecuniary reasons goes down; as such it during boom times that we would expect to see increases in intra- and inter-urban competition.

This paper does not directly address how technological change has altered the market for height in New York and Chicago.[14] New lighter ma-

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[12] Schultz and Simmons (1959) argue that to some degree height limitations in Chicago kept down economic growth. They write that during the height limitations period, "New York could and did building office buildings to house the great expansion of business. Some of this business wanted to come to Chicago and would have if it could have been accommodated there" (pps. 286-287).

[13] Given the underlying building data, we have $\widehat{st.\,dev.\,height}_t = \underset{(2.7)}{6.8} + \underset{(1.3)}{12.9}\ln count_t + \underset{(3.4)}{6.9}\,Chicago + \underset{(2.2)}{4.8}\ln count_t \times Chicago$

$R^2 = 0.43$, # obs.=172. Robust standard errors below estimates. All coeff. stat. sig. at 95% or greater.

[14] The role of technological change in the market for height remains unstudied. See Landau and Condit (1996) for a detailed chronicle of the evolution of skyscraper technology in the late-19th and early-20th century. Articles such as those in *Science Illustrated* (2009)

terials, such as glass, have been substituted for older ones, such as stone and brick; computer-aided design has allowed engineers to develop more efficient building systems. The use of efficient boring and drilling methods allow for skyscrapers in areas with less than idea subsoil conditions. Interestingly, Barr (2010) finds that the tallest skyscrapers in New York, are not, on average, becoming taller nor are they more frequently constructed. In other words, technological change does not necessarily manifests itself with additional height.

4 New York and Chicago

4.1 Economic Interactions

Clearly New York and Chicago directly benefited from the exchange of goods and services, capital and ideas.[15] Chicago was first platted in 1830 in anticipation of the construction of a canal that would connect Lake Michigan to the Mississippi River. The Illinois and Michigan Canal was eventually completed in 1848, the same year a Chicago's first railroad, the Galena and Chicago Union (Cain, 1998). With the settling of Chicago and the opening of the Erie Canal in 1825, Chicago and New York's economies became linked. Chicago became the urban hub of the old northwest, as it was the central marketplace for the vast hinterland's agriculture and natural resources (Cronon, 1991; Cain, 1998).

These goods were then shipped via the Erie Canal and railroads to New York, where they were then sold along the east coast or were shipped to European markets. Finished products and immigrants travelled west. Eastern merchants and investors provided Chicago and the region with capital for land development, construction and business growth (Haeger, 1981; Cronon 1991).

Chicago's Great Fire of 1871 spurred even more real estate related interactions. Since the fire swept away most of Chicago's downtown, new methods

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detail more recent innovations.

[15] Interestingly, there does not appear to be a detailed account regarding the degree to which New York and Chicago engaged in trade. Accounts such as those in Haeger (1981) and Cronon (1991) describe the growth of Chicago and the Old Northwest. To some degree they chronicle the extent to which eastern capitalists and entrepreneurs invested in the region; but they do not provide specific measurements of the urban-level current and capital accounts between the two cities.

of fire-proof construction and tall building were implemented in the 1880s (Schultz and Simmons, 1959). This knowledge was then transferred to New York, where steel construction was introduced in 1889.

Architects, engineers and builders who first "cut their teeth" on Chicago's first generation of skyscrapers where employed in New York as well. This interaction has lead Zukowsky (1984) to write:

> Chicago and New York–these are often thought to be the two great superpowers of American architecture. Architects consider each city to have its own style, its own way of shaping its local environment, its own individualistic contributions to the history of architecture Yet these contributions were not developed in isolation. Throughout the 19th and 20th centuries there has been, and still is, a considerable amount of competitive interactions between architects, contractors, and developers in both cities (p. 12).

The list of past and present interactions is long, and can be the subject of a whole book, but here I just list a few important examples. In the early period, perhaps Chicago's most famous skyscraper architect, Louis Sullivan, designed one of his signature buildings in New York (Bayard Building, 1899). Builder and skyscraper pioneer, George Fuller and his firm built skyscrapers, such the Monadnock (1893) and the Rookery (1888) buildings in Chicago, and the New York Times (1904) and Flatiron (1902) buildings in New York City, which was also designed by one of Chicago's most famous architects, Daniel Burnham.

Competition between the two cities in this early period was keen. For example, the *Chicago Daily Tribune* (March 11, 1900) reports a typical case of interest:

> The newest thing in the racing field is the skyscraper. It involves Chicago and New York, and as usual Chicago is in the lead. A novel race of skyscrapers has been in progress for nearly a year at Cedar Street and Broadway, were two sixteen-story office buildings are going up on opposite corners....The American Exchange National Bank Building is being erected on the northeast corner by a New York firm of builders, and on the northwest corner Chicago contractors are putting up the St. Lawrence Building....The Chicago firm celebrated its triumph today by hanging

> out a sign announcing that its building will be ready for occupancy in May. The New York firm admits that it can only finish in time for the autumn renting (p. 2).

In the 1920s, architect Raymond Hood, who resided in New York, designed both the Chicago Tribune Tower (1924) and the New York Daily News Building (1929). After World War II, German-born architect Ludwig Mies van der Rohe, head of the architecture department at Chicago's Illinois Institute of Technology, designed one of New York's most famous modernist buildings, the Seagram Building (1958). The architecture firm Skidmore, Owings and Merrill (SOM), founded in Chicago in 1936, has designed many buildings in the two cities, including the Sears Tower (1974) and the John Hancock Tower (1969) in Chicago and the Lever House (1952) and One World Wide Plaza (1989) in New York. Lastly, New York based builder Donald Trump, who has built many skyscrapers in New York, in 2009 completed the 92 story Trump International Hotel and Tower (designed by SOM) in Chicago.

4.2 New York's Zoning and Policies

New York's first "skyscraper," the Tower Building, was completed in 1889, four years after Chicago's first, the Home Insurance Building. After that, steel-cage construction in New York became common place. 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). Partly as a result of the emergence of skyscrapers, in 1916, New York City implemented the first comprehensive zoning legislation that stated height and use regulations for all lots in the city. In 1961, New York City implemented an updated zoning law.

Unlike Chicago, for example, New York has never directly capped the heights of buildings. Rather the 1916 code created set-back requirements. That is, buildings had to be set back from the street based on some given multiple of the street width. The 1961 code put limits on the total building volume by setting so-called floor area ratios (FARs) in different districts.[16]

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[16] The FAR gives total building area as a ratio of the lot size. For example, a FAR of 10 means that total floor area can be ten times the lot area. Thus, a builder would have

Presumably New York's response to building height would have implications for how its skyline developed as compared to Chicago's.

In the 1970s and 1980s, New York implemented three additional programs that were designed to promote high rise construction. From 1982 to 1988, a special midtown zoning district was created to encourage development on the west side of midtown by allowing volume bonuses of up to 20%. 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. 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.

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.

4.3 Chicago's Zoning

Between 1893 and 1923, Chicago placed direct limits on the height of buildings. Table 1 summarizes the building height regulations in New York and Chicago. In 1893, Chicago imposed a 130 foot limit on the height of buildings (about 10 stories or 39.5 meters). Several more towers were completed after 1893, since the permits for these building were issued prior to the implementation. In 1902, the building height limit was doubled to 260 feet; but only nine years later in 1911, the maximum height was reduced to 200 feet.[17]

In 1920, a new approach was taken. The height limit was raised again to 260 feet, but builders were also allowed to construct ornamental towers that could rise to 400 feet (though these towers could not be occupied). Then

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the choice of constructing a 10 story building that covers the entire lot or, say, a 20 story building that covers half the lot.

[17] Evidently, the economic interactions between the two cities did not preclude tongue-and-cheek comments from the New York Times. On March 2, 1902, (page 10), the paper reported, "That sky-scraper limit [in Chicago] has now positively been fixed at 260 feet, until some one comes along who wants to a build a taller one."

Year Implemented	Chicago	New York
1893	130′ (39.6m) limit	
1902	260′ (79.2m) limit	
1911	200′ (61.0m) limit	
1916		Setback multiple
1920	260′ limit + 400′ for tower (total 183m)	
1923	264′+tower, with area and volume limits	
1942	144×lot size (FAR≈12)	
1957	FAR limits + bonus	
1961		FAR limits + bonus

Table 1: Building height regulations in Chicago and New York.

in 1923, the height limit was raised to 264 feet and habitable towers were permitted. Though there was no limit on tower height, they area of the tower had to be less than 25 percent of the plot area and less than one-sixth of the volume of the main building. These rules were in effect until 1942. In that year a more flexible approach to height was implemented. For much of downtown Chicago, the maximum building volume was capped at the area of plot times 144 feet. This gave builders the equivalent of a floor area ratio of roughly 12. Given the Great Depression and World War II virtually no skyscrapers were built during this zoning period.

Finally, starting in 1957 the current approach was implemented. Builders were given floor area ratio (FAR) caps (a similar set of rules was implemented in New York, starting in 1961). In downtown Chicago, builders had a FAR of 16; FAR bonuses were given if builders provided open space around the building. As in New York, these regulations promoted the boxy towers that are common today.

Causes and Effects A detailed discussion of why Chicago capped heights, but not New York, is beyond the scope of this paper.[18] However, the policy decisions made represent the outcome of complex set of "negotiations" between the interested parties, including, but not limited to, skyscraper de-

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[18] For a detailed discussion of the history of zoning in Chicago see Schwieterman and Caspsall (2006). See Weiss (1992) for a history of building height restrictions in New York and other cities.

velopers, current landlords and businesses, insurance companies, politicians, engineers, architects, planners and the public at large. Within each city, because of the differing historical interactions of these groups, and the differing history, geography and economies of the cites, each place came to a separate decision about its "preferences" for building height.

Chicago was not alone in its decision to cap it heights. Large, industrial cities throughout the U.S. placed restrictions on height, since it was seen as a solution to the various tradeoffs associated with skyscrapers (Weiss, 1992). Generally speaking, the debate about building height related to the tradeoffs involved between promoting the creation of building space and reducing the externalities it may cause, such as increased congestion and shadows on the street and surrounding buildings; and the loss of rent revenue by existing landlords due to either these shadows or the additional square footage put on the market (Willis, 1996; Weiss, 1992). In addition, aesthetic concerns also appeared prominently in the debate, as some people viewed skyscrapers a the architectural embodiment of ugly, partly because they seemed new and monstrous relative to the buildings they replaced.[19] In the early years of the skyscraper, the history of Chicago's great fire also contributed to safety fears about these new types of buildings.[20]

The question posed here is: To what extent does the evidence suggest that these building height restrictions had a meaningful impact on the skyline, itself? On one hand, height restrictions can be based on a strong "distaste" for height, and as such, the city can impose height restrictions to improve city-wide utility (that is the skyscraper highrise interests might be dominated by the lowrise interests). On the other hand, the height restrictions themselves, might simply have been a legal embodiment of what the economic climate would have generated anyway; that is to say, builders and landlords might

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[19] A letter to the *Chicago News,* and reprinted in the *New York Times* (1895), writes, "The amendment [to limit heights to 130 feet] was made after a careful investigation of the subject...and in response to a very general sentiment that the sky-scraper was a mistake....[E]verybody, save possibly a few blind men, objected to them on the ground of their ugliness" (p. 14).

[20] "Chicago, Dec. 17.–No more cloud-pushing buildings will be erected in Chicago....[T]he Chicago Fire Underwriters' Association settled the whole thing by adopting, at its meeting last night, a resolution that all office buildings of non-combustible construction should be limited in height...to 120 feet....This means that on buildings of more than the prescribed height insurance cannot be obtained in any of the companies composing the Under-writers Association except at a rate premium which is practically prohibitive." (New York Times, 1891)

	Chi Count	**NYC Count**	**Chi Max**
NYC Count	0.76		
Chi Max	0.79	0.67	
NYC Max	0.64	0.71	0.57

Table 2: Correlation coefficients for number of skyscraper completions (Count) and tallest completed building (Max) in New York and Chicago from 1885 to 2007.

have implemented height restrictions against would be ego-based builders, who did not care, say about the effects of non-pecuniary motivated height on the market place. These issues are explored below.[21]

5 The Determinants of the Skylines

Here we briefly discuss the data used in the paper. Specific details about data sources and preparation are given in Appendix A. Figure 1 shows skyscraper patterns in New York and Chicago from 1885 to 2007. The top graph shows the annual number of skyscraper completions and the bottom graph show the height of the largest building constructed each year (in meters).

The first thing to notice is that skyscraper building is cyclical in nature. These cycles are in the order of decades rather than years. For both cities, the peaks and troughs occur roughly at the same time. In fact, as seen in table 2 there is a high degree of correlation across the times series.

However, despite the large correlations, there are notable differences between the two cities. In terms of completions, the late-1920s/early-1930s and the mid-1980s show the greatest divergences across cities. Evidently the building boom in Chicago in the 1920s was less dramatic.[22] In New York City the rise in the number of completions in the 1980s appears to be due, in part, to the implementation of three programs in New York City: a zoning bonus

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[21] The question on how these skyline restricted or affected urban growth is more complex to understand since height restrictions may be a response to overbuilding, in addition to possibly lowering or spreading out future construction. To what extent did Chicago lower its economic growth because of these restrictions? This remains for future work.

[22] Interestingly, there does not appear to be a detailed accounts for the reasons behind New York City's skyscraper building boom in the late 1920s. Despite Clark and Kingston's (1929) work on the "rationality" of 63 story skyscrapers, and the handful of height races, it appears that the building boom was a classic example of a real estate bubble.

to encourage development on the west side of Manhattan's midtown business district and generous residential and business tax abatement programs.

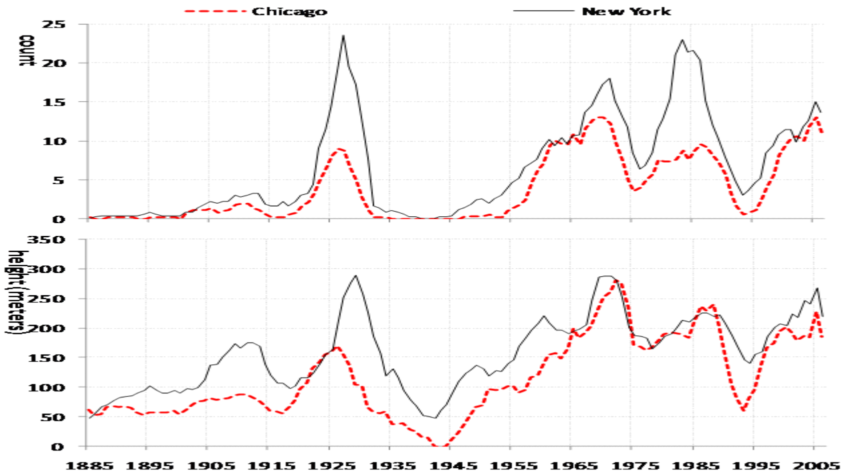

Figure 1: Top Graph: MA(5) of number of skyscraper completions in New York and Chicago, 1885 to 2007. Bottom Graph: MA(5) of height of tallest building completed each year in New York and Chicago, 1885 to 2007. Sources: See Appendix A.

Looking at the height graph (bottom of Figure 1) we can see that from about between 1889 and 1966, New York was consistently building taller buildings than Chicago. From the mid-1960s, interestingly, Chicago and New York's tallest buildings have been comparable; this may in part be due to the similar zoning regulations in effect in the two cities. The peak in New York around 1930, shows the heights of the Chrysler and Empire State Buildings. The peaks in the mid-1970s is from the completion of the Twin Towers in New York and the Sears Tower in Chicago.

Interestingly, in the post-World War II period both the number of skyscrapers (*count*) and the heights of the tallest buildings (*max*) have not been getting taller, on average. Table 3 presents the results of regressions of the various city dependent variables on a time trend. As the table shows, in all cases for the full sample, there is a time trend. But in all cases from 1955 to 2007 there is no trend. This suggests that there is a kind of spatial equilibrium at work. If inter-city interactions are present, it would appear that, in some sense, it is a zero-sum game. That is to say, if a city builds

Variable	Time Period	Coefficient	p-value	R^2	# obs
Chi Max	1885-2007	1.22	0.00	0.29	123
Chi Max	1955-2007	0.40	0.51	0.01	53
Chi Count	1885-2007	0.07	0.00	0.31	123
Chi Count	1955-2007	0.01	0.83	0.00	53
NYC Max	1885-2007	1.17	0.00	0.29	123
NYC Max	1955-2007	0.37	0.47	0.01	53
NYC Count	1885-2007	0.11	0.00	0.25	123
NYC Count	1955-2007	0.04	0.40	0.01	53

Table 3: Results of regressions of the city dependent variables on a time trend, i.e., the coefficient $\hat{\beta}_1$ is estimated from the model $y_{i,j} = \beta_0 + \beta_1 year + \varepsilon$, where $y_{i,j}$ is skyscraper measure j in city i.

extra buildings to attract jobs and population it would then have this extra building "countered" by the other city, which, in some sense, would offset the gains that the other city enjoyed.

5.1 Regression Analysis

The purpose of this section is to estimate the determinants of the skyline in New York and Chicago from 1885 to 2007, with a focus on two variables, the number of skyscraper completions in the two cities, $ln\,(1 + count)$, and the height of the tallest building completed each year, max. Here we can test several hypotheses regarding the two cities:

1. Are the coefficients that determine the skyline the same or different across the two cities? If different, what are the major differences?
2. Is there evidence of skyscraper market interactions across cities?
3. How have zoning regulations affected the two skylines?
4. Controlling for the relative supply and demand variables, which city is more prolific?

Barr (2010) provides a supply and demand model for both skyscraper height and the number of completions. Here I briefly describe this model as it used for a guide for estimation, but the reader is referred to that paper for more information.

Skyscraper developers aim to maximize profits (or utility) from construction. The return to construction is the discounted per floor net rent times the number of floors. The cost of construction is assumed to be increasing at an increasing rate, after some height. Thus the profit maximizing height is the one that sets the per floor discounted rent equal to the marginal cost.[23]

On the demand side, office-based firms have a demand for space (height) as a function of the price (the rental value) and exogenously determined employment. If we assume that at any given time the current stock of space is fixed so that the quantity of space supplied is equal to the quantity demanded, then it can be shown that at any given time the equilibrium height that developers will supply is a function of measures of the demand for space, the current stock of space, and the costs of construction (which include the cost of materials, interest rates and the access to capital, for example).

Furthermore, if we assume that the number of potential skyscraper plots supplied to the market is a positive function of land values, and land values are residual profits from construction, then it can be shown, as in Barr (forthcoming), that the number of completions will be a positive function of the demand-side variables and negatively related to the cost of construction.[24]

Lastly, if the relative height of one skyline affects the utility of builders in the other city, then we would expect to see builders adding extra height to their building, beyond the profit maximizing amount, so they can maintain their relative position (or try to strategically jump ahead). Thus if city-wide strategic interaction, due to "urban pride,"or regional growth is important we would expect to see the height decisions of one city affecting the height decisions in the other city.

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[23] It is it likely that rents rise with heights, but, for a given plot size (the types readily available in New York and Chicago), at some point, they cannot rise faster than marginal costs and/or elevator banks would likely take up too much space on the lower floors to remove the incentive to keep building to the heavens.

[24] Note that in the regressions below, I do not include measure of land values. Since we are looking at the height market as a whole we use supply and demand variables instead. In addition measures of the total value of land in Manhattan and Chicago do seem to exist over the entire sample period.

5.1.1 The Data

Table 4 gives the descriptive statistics of the data set used in this paper. Appendix A gives the details about the sources and the preparation. To estimate the demand for both height and skyscrapers in general, I have included the following variables. First, is the detrended log of real Gross Domestic Product (GDP). This variable aims to measure the degree to which growth above or below the long run trend rate of 3.2% affect skyscrapers. As noted above, skyscraper development is highly cyclical; the aim of this variable is to see how much of these cycles are affected by the cyclical component of economic growth. A second demand variable is the percent of U.S. employment in the Finance, Insurance and Real Estate (FIRE) sectors. This is clearly important since skyscrapers are driven primarily by office employment.

{Table 4 about here}

I also include two measures of stock market activity which presumably would affect the demand for skyscrapers. First is the percent change in the Standard and Poor's Stock Index (S&P). When the value of the S&P is increasing, it means firms are more profitable and they are more likely to be increasing both their demand for office space, and potentially using some of those profits to engage in height advertising.

As a second measure, I include the log of average daily volume of the New York and Chicago stock exchanges, respectively. In theory, the more trading activity, the more profits will go to finance-based firms, who will then demand more office space and height. A final demand variable is an estimate of the annual regional populations in the two cities. We would expect that as the regional population increases, it will increase land values in the center, which will then increase both the number of skyscrapers and the height of buildings, cet. par. For all of the above-mentioned variables we would expect to see positive coefficients.

In terms of supply side variables, I include the percent change in the dollar value of real estate loans made each year by commercial banks. This is a measure of the supply of construction capital. I also include the real interest rate as a measure of the cost of capital. To measure construction costs I include an index of the real value of construction materials. Finally, for each city I also include the net cumulative number of skyscraper completions in each city (90 meters or taller for both cities) as a measure of the total stock of skyscrapers. For interest rates, materials cost and cumulative completions, we would expect to see negative regression coefficients, but positive ones for growth in real estate loans. For each city I include dummy variables for the various zoning regulation regimes discussed above. For zoning variables we would expect negative signs. For New York's building incentive program we would expect to see positive signs.

I also include measures of the plot sizes. As discussed in Barr (forthcoming; 2010) plot size is an important component of the economics of skyscrapers since it affects both the marginal costs and benefits to height. However, it might be endogenous if builders who have a particular desire to build tall seek out the extra large plots. In the end, I have included this variable. Despite its potential endogeneity, the exclusion of the variable seems to be potentially more harmful to the estimation than its inclusion, because of possible omitted variable bias. Barr (forthcoming) however does not find evidence for plot size endogeneity for New York City. The determinants of plot size are often out of the control of builders (due to holdouts, unusual plot shapes, the placement of roads and railroads near some blocks) and thus there is no strong *a priori* reason to assume that endogeneity is a major problem in this regard.

Also a note is in order about national versus local variables. To the extent possible, I have aimed to collect city- or regional-specific variables. But for some of the demand and supply variables, such local measures are not available over the entire sample period. While measures of office employment and construction costs do exist they tend to be available for the post World War II period or may be available for some years for one city and not another. For this reason, I have only included variables that I have been able to obtain for at least 100 years, which can be local or national in scope.

In addition, national variables can be useful measures. First we are dealing with large cities and as such they are connected to the national economy and are presumably affected by it; second the variation across regions is often small relative to the variation across years, i.e., there is high correlation between US and local measures for a given year; and lastly, using the same measure allows us to see how they affect the two cities differently.

Finally, for the majority of the variables, the right hand side variables are lagged two years. This makes sense given the time between ground breaking and completion. In some cases, lags of three years provided a better fit of the data; this was the case for finance related variables, since presumably financing must first be arranged before construction can begin.

5.1.2 Responses to Fundamentals

Table 5 provides the regression results for the log of one plus the number of completions; Table 6 provides the results for the tallest building completed in each city.[25] The regression results present models of the economic determinants of skyscrapers, while section 5.1.3 below presents results that aim to measure strategic interaction.

{Table 5 about here}

{Table 6 about here}

Regression (1) in each table gives the combined regression for both cities (i.e., for a panel of New York and Chicago). In general, the combined regressions provide a good fit to the data. Almost all of the coefficients have the expected signs. We see that, in general, skyscraper building responds positively to national output and FIRE employment, the growth in real estate loans and regional population. Skyscraper construction responds negatively to the total stock and building materials costs. Interestingly, the interest rate is not strongly negative as one would predict; in the combined regressions, it is positive. The reason behind this effect is left for future work.[26]

In Table 5, equations (2) and (3) present regressions for just Chicago. Equation (2) is the number of completions that are 80 meters or taller, and equation (3) is for buildings that are 90 meters or taller. Generally speaking the two equations give broadly the same results. Equation (4) is just for New York City.

Comparing the coefficients from say equation (2) and equation (4) suggests that there are some differences in how the two cities respond to the

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[25] Note that for the maximum height regressions, the dependent variable is in levels. This was done for two reasons. First, since during some years in the period 1933 to 1948 in Chicago no buildings were completed (or at least none that were important enough to be catalogued on www.emporis.com, www.skyscraperpage.com or in Randall, (1999). Leaving the variable in levels allows it to be a continuous real value greater or equal to zero. If I take the log of the variable (or one plus the log), I introduce discontinuities which might affect estimation. Second, in Barr (forthcoming), in the case of New York, I find that levels appears to better fit the data for average heights than logs.

[26] Maccini, et al. (2004) show that interest rate regime switches need to be included in the model to better capture the effect of interest rates on capital investments.

underlying economic fundamentals. For example, Chicago seems more responsive to GDP growth than New York. In general, for costs, population, stock exchange volume, and real estate loans the estimated coefficient is larger in New York than in Chicago. For Table 6, we see some similar results. Chicago's skyline height is more sensitive to GDP than New York. But the effect of total stock, materials costs, population and stock volume New York appears to be more sensitive than Chicago.

Table 7 presents the results of χ^2 tests, with the null hypothesis that individual coefficients for Chicago are equal to those of New York City. The table presents the p-values for the test (so that a p-value of 0.1 or less would suggest that the coefficients for the two cities are different). For the count equations, we see that most of the variables have different coefficients (though the two financing related variables are not different). In addition, the evidence suggests that the effect of plot size is the same. The factors that drive the height of the tallest building are more likely to be the same in the two cities, but the effect of plot size is different.

5.1.3 Strategic Interaction Effects

To test for interaction effects across cities, I estimate a four equation system using a seemingly unrelated (SU) regression, where

$$Y_t' = \{\ln(1+count)_{Chi,t},\ \ln(1+count)_{NYC,t},\ \max_{Chi,t},\ \max_{NYC,t}\}\,.$$

Two different sets of SU regressions were run. The first set (SUR 1) includes all of the right hand side variables presented in tables 5 and 6. The second (SUR 2) includes in each equation all of the right hand side variables from above and a lagged dependent variable. That is to say, one set of regressions estimated the system $Y_t = X_t'B + U_t$ and the other estimated the system $Y_t = X_t'B + Y_{t-1}'D + U_t$, where B and D are vectors of coefficients (and D only has non-zero terms along the main diagonal).

By looking at the correlation across residuals I can investigate the degree to which non-economic factors from one city affect the other. That it to say, the variables in each regression allow us to control for the economic and policy factors that drive skyscraper completions and height in each city. The residual can thus be interpreted as the non-economic factors that drive height. If we see a positive correlation, for example, of the residuals from one city with the residuals of the other, we can interpret this as a strategic effect.

The inclusion of a lagged dependent variable is a way to control for possible lagged effects in the building decisions. Since the time to completion can vary several years, the lagged dependent variable is a way to control for this and other omitted variables. This is important because there may be similar economic variables driving the skylines of the two cities and if we are to investigate inter-city effects, the inclusion of a lagged dependent variable would more likely control for unmeasured city-specific effects that might confound inter-city effects. In addition, the inclusion of the lagged dependent variables remove any serial correlation of the errors that might have been present in the four dependent variables.

Two tables are presented. Table 8 give the results for the counts for Chicago and New York, presenting the results of the two different SU regressions side-by-side. This is done to show how the inclusion of the lagged dependent variable affects the coefficients of the other variables. Table 9 gives the results for the tallest building completed each year in the two cities. To the extent that there is correlation among the residuals, an SU model can increase the efficiency of the model.

{Table 8 about here}

{Table 9 about here}

In general the regressions show similar results across specifications and similar to the OLS models presented in section 5.1.2. In all cases, the lagged dependent variables are statistically significant with greater than 99% confidence. They add about 2 to 3 percentage points to the total explanatory power of the regressions. The coefficients range from values of 0.23 to 0.375. The general effect of the lagged dependent variables is to reduce the magnitude (in absolute value) of the coefficients and to reduce their levels of confidence. However, all coefficients retain their signs as compared to the models without them.

From these regressions I investigate the degree of correlation among the residuals, with a particular focus on how the cross-city residuals are related. Table 10 gives the correlations among the residuals across cities. As the table shows, there is positive correlations between the Chicago count and height and New York City counts, in both SUR 1 and SUR 2. Interestingly, the correlations with Chicago max and New York City max are negative (weakly in SUR 1 but more so in SUR 2).

{Table 10 about here}

To explore in more detail the relationship between the residuals, regressions were run to see how the residuals and their lags of one city affect the residuals of the other. Table 11 gives the descriptive statistics for the four residuals from the second regression (SUR 2). These tables provide evidence on the nature of the strategic best response functions.

{Table 11 about here}

To find a good specification for each equation, I maximized the adjusted R-square (i.e., variables were included if the t-statistic was greater than one). Table 12 presents the results.

{Table 12 about here}

Interestingly, the regressions show evidence for both positive and negative best response functions. For the counts variables, we see that for both cities, the number of completions responds positively to the count in the other, suggesting that developers see the counts in the other city as a strategic complements.

For the height decisions, we see a bit more complicated picture. New York's height appears to negatively respond to Chicago's height, while, on net, Chicago seems to positively respond to New York's height. Thus for New York we see evidence of strategic substitutes in regard to height, but for Chicago we see evidence of strategic complements. Overall the fact all four equations have at least one positive coefficient from the other city's variables suggest the presence of some degree of "skyline competition."

5.1.4 Restrictions and Height Productivity

Returning to equation (1) of Table 5, the city-specific dummy variables show some interesting differences across the cities (each city-specific dummy variable is interacted with a city dummy variable, thus each zoning variable, for example, is interpreted as the effect that of that variable in that city compared with the other city). In addition, a Chicago dummy variable is included as well to capture a general Chicago-wide effect that may be present. For example, in Table 5, equation (1), shows a positive Chicago effect of 3.88, which suggest, *that all else equal*, Chicago was actually a much more productive skyscraper city (if we use 90 meters or greater in the combined equation the Chicago dummy coefficient only drops to 3.13. Results available upon request). The introduction of height caps, of course, reduced the number of completions and height of the maximum amount. But equation (1) in table 5 shows that zoning rules in effect in early 1920s (260 foot cap with ornamental tower) appears to have actually been the most restrictive, as compared to New York City at the same time. Similarly, equation (1) in Table 6 shows that, ceteris paribus, Chicago's tallest buildings were actually 191 meters (about 16 floors) taller, on average, than New York City.

In regard to zoning, an F-test shows that the zoning coefficients for Chicago (from equation (2), Table 5) are jointly different than zero. The F-statistic is F(7, 95) = 2.72, with a p-value of 0.0130. Similarly for equation (2), table 6, the F-stat. for the zoning coefficients is F(7, 95) = 1.98, with a p-value of 0.066. These results would suggest that in general zoning restrictions in Chicago had real economic consequences, and were not simply legal manifestations of the economic heights of the time.

6 Conclusion

This paper has investigated the market for skyscrapers in New York City and Chicago from 1885 to 2007. The aim of the work is to compare and contrast the annual time series for the number of skyscraper completions and the height of the tallest building completed in each city. I estimate a market model of skyscraper activity in the two cities. The results suggest that overall New York City's height market has greater elasticity with respect to the underlying economic fundamentals, such as employment and construction costs. Inter-city competition effects are also tested with these regressions; I find evidence for "skyline competition." I also test for the effect of Chicago's height cap limitations on the height market and find that these caps significantly reduced both height and completions over the 20th century. However, in general, controlling for other factors that drive the skyline, Chicago appears to be more prolific than New York, ceteris paribus.

This work here is but a first attempt to understand the causes and consequences of skyscrapers in the United States. Since the economics of skyscrapers remains an understudied area, there are many possible extensions for future work. One area includes how the number and density of skyscrapers has affected the growth of cities over the 20th century. Relatedly, further work can investigate the degree to which height restrictions in various cities have (a) altered the spatial distribution of economic activity within the cities and (b) have impacted economic growth in these cities. Future work can also look at the impact of technological change on the economics of skyscrapers. No work to date has directly investigated how the evolution of new building methods and materials has affected the market for height. The work here can also be expanded to include more cities to see if there is evidence of multi-city competition with regard to skyscraper height.

A Data Sources and Preparation

- Completions, Maximum Heights and Net Cumulative Completions: skyscraperpage.com and emporis.com (year of demolitions were found from NY Times or Randall (1999)).

- Plot Size: New York City: http://gis.nyc.gov/doitt/nycitymap/ and various editions of the New York Land Books. Chicago: Sanborn Fire Insurance Maps and http://maps.cityofchicago.org/kiosk/mpkiosk.jsp.

- Detrended GDP: Annual real GDP is from measuringworth.com. ln(Real GDP) was regressed on the year. The residual of this regression is the variable used.

- Percent of national employment in FIRE: See Barr (2010).

- Real Materials Costs: See Barr (2010).

- Regional Populations: U.S. Census Bureau. For New York: Population included 5 boroughs of NYC, Nassau, Suffolk, Westchester, Hudson and Bergen counties. For Chicago, population was from Cook, DuPage, Kane, Lake, Will and Lake (Ind.) counties. 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/data year, i.e., $i \in \{1890, 1900, ..., 2000, 2007\}$, t is the year, and β_i is solved from the formula, $pop_i = pop_{i-1}e^{10*\beta_i}$.

- % Change in Real Estate Loans: See Barr (2010)

- % Change in Standard and Poor's Stock Index: Historical Statistics of United States, Millenial Edition; yahoo.com

- Real Interest Rates. See Barr (2010).

- Stock Exchange Volumes: New York: See Barr (2010). Chicago: Palyi (1937/1975) and various SEC Annual reports.

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Variable	**Mean**	**St. Dev.**	**Min.**	**Max.**	**# Obs.**
New York Skyscrapers					
Max Height (m)	158.34	78.45	18.0	417.0	125
Completions	6.64	7.70	0.0	37.0	125
Net Total Completions	278.80	247.28	1.0	814.0	120
Avg. Plot Size (sq. feet)	43,820	36,564	5,198	241,478	98
Plot size of max.	59,743	105,480	1,787	681,600	123
Chicago Skyscrapers					
Max height (m)	116.55	84.52	0.00	442.30	125
Completions (80m+)	3.93	4.93	0.00	23.00	125
Completions (90m+)	2.87	4.02	0.00	18.00	125
Net Total Completions (90m+)	94.98	103.69	1.00	354.00	125
Avg. Plot Size (80m+)	41,244	22,369	9,000	143,828	73
Avg. Plot (90m+)	47,569	30,926	9,000	212,137	62
Plot size of max	45,719	44,601	4,080	282,492	112
U.S. Variables					
ln(RGDP) Detrended	0.00	0.12	-0.47	0.20	123
FIRE Emp./Emp. (%)	4.52	1.42	1.94	6.57	118
Real Material Cost Index	1.22	0.25	0.82	1.61	124
%ΔUS Real Estate Loans	8.22	8.43	-19.10	42.17	117
%ΔS&P Index	6.37	18.05	-48.50	49.90	123
Real Interest Rates (%)	2.25	4.81	-14.76	19.57	123
New York Economic Variables					
Regional Population (M)	11.10	4.09	3.09	16.00	123
Zoning Dummy (1916-1960)	0.36				125
NYSE Volume (B)	36.66	100.04	0.033	532.02	120
Zoning Dummy (1961-2007)	0.38				124
Zoning Bonus Dummy (1982-1988)	0.06				124
Tax Abatements Dummy (1971-1985)	0.12				124
ICIP Dummy (1977-1992)	0.13				124
Chicago Economic Variables					
Regional Population (M)	5.19	2.33	1.00	8.59	124
Chi. Ex. Stock Volume (B)	1.79	5.50	0.0002	30.13	116
Cap 130' Dummy (1893-1901)	0.07				125
Cap 260' Dummy (1902-1910)	0.07				125
Cap 200' Dummy (1911-1919)	0.07				125
Cap 260'/400' Dummy (1920-1922)	0.02				125
Cap 264'/Tower Dummy (1923-1941)	0.15				125
Limit 144×Plot Dummy (1942-1956)	0.12				125
FAR Limits Dummy (1956-2007)	0.42				125

Table 4: Descriptive Statistics. See Appendix for sources.

	(1)	(2)	(3)	(4)
	Combined	Chicago $80m+$	Chicago $90m+$	NYC
ln(RGDP Detrend)$_{t-2}$	1.52 (3.5)**	2.06 (2.3)*	2.09 (2.6)*	0.12 (0.2)
ln(FIRE)$_{t-2}$	1.17 (2.9)**	0.92 (1.5)	0.10 (2.0)*	0.96 (1.7)
ln(Total Stock)$_{t-2}$	-0.95 (5.7)**	-0.60 (2.4)*	-0.31 (1.5)	-2.24 (7.2)**
ln(Materials Costs)$_{t-2}$	-2.49 (5.0)**	-1.27 (1.6)	-1.02 (1.6)	-3.97 (4.8)**
ln(Stock Volume)$_{t-2}$	0.06 (2.1)*	0.03 (0.4)	-0.02 (0.4)	0.26 (4.9)**
ln(Metro Pop)$_{t-2}$	4.24 (6.0)**	2.17 (1.9)	1.48 (1.7)	9.80 (7.8)**
%ΔRE Loans$_{t-3}$	0.02 (4.0)**	0.01 (1.9)	0.01 (2.3)*	0.02 (3.0)**
%ΔS&P Index$_{t-3}$	0.004 (2.3)*	0.004 (0.2)	-0.001 (0.5)	0.008 (3.0)*
Real Rates$_{t-3}$	0.01 (1.9)	0.02 (2.0)*	0.01 (1.8)	-0.001 (0.1)
NYC Zoning Bonus$_{t-2}$	0.59 (2.9)**			0.56 (2.4)*
NYC Tax Abatement$_{t-2}$	0.34 (2.4)*			0.53 (3.2)**
NYC ICIP$_{t-2}$	0.12 (0.6)			0.57 (2.2)
NYC Zoning 1916$_{t-2}$	0.14 (0.6)			-0.15 (0.5)
NYC Zoning 1961$_{t-2}$	0.31 (0.9)			-0.45 (1.1)
Chi Zoning 130$_{t-2}$	-0.50 (2.3)*	-0.14 (0.6)	0.03 (0.2)	
Chi Zoning 260$_{t-2}$	-1.05 (3.8)**	-0.38 (0.9)	-0.20 (0.6)	
Chi Zoning 200$_{t-2}$	-1.46 (4.0)**	-0.44 (0.7)	-0.29 (0.6)	
Chi Zoning 260/400$_{t-2}$	-2.14 (3.7)**	-0.73 (0.9)	-0.53 (1.0)	
Chi Zoning 264+tower$_{t-2}$	-1.34 (3.2)**	-0.06 (0.1)	-0.08 (0.1)	
Chi Zoning plot×144$_{t-2}$	-1.71 (4.0)**	-0.46 (0.4)	-0.60 (0.9)	
Chi Zoning FAR$_{t-2}$	-1.64 (3.2)**	-0.04 (0.0)	-0.22 (0.3)	
Chicago Dummy	3.88 (5.9)**			
ln(Avg. Plot Size)	0.11 (13.0)**	0.11 (8.5)**	0.10 (6.23)**	0.09 (7.1)**
Constant	-66.0 (6.2)**	-32.1 (1.7)	22.3 (1.0)	-151.5 (7.8)**
Observations	227	113	113	114
R^2	0.84	0.85	0.85	0.85
$\bar{R}^2$	0.82	0.83	0.83	0.82
Durbin Watson Stat.		1.19	1.27	1.67

Table 5: Regression Results for Number of Skyscraper Completions , 1885-2007 (dep. var is $ln(1+count)$). Eq. (1) includes robust standard errors, Eqs. (2)-(4) include Newey-West standard errors. *Stat. Sig. at 95% level; **Stat. Sig. at 99% level. See Appendex for sources.

	(1) Combined	(2) Chicago	(3) NYC
ln(RGDP Detrend)$_{t-2}$	162.1 (2.8)**	296.4 (3.5)**	51.3 (0.5)
ln(F.I.R.E.)$_{t-2}$	102.5 (3.0)**	107.0 (2.0)*	76.1 (1.4)
ln(Total Stock)$_{t-2}$	−38.3 (2.4)*	−2.29 (0.1)	−135.3 (3.8)**
ln(Materials Costs)$_{t-2}$	−199.7 (3.4)**	−121.4 (1.3)	−297.4 (3.0)**
ln(Stock Volume)$_{t-2}$	1.47 (0.4)	−8.34 (1.2)	20.9 (3.7)**
ln(Metro Pop)$_{t-2}$	258.7 (3.7)**	161.9 (1.4)	633.7 (4.2)**
%ΔRE Loans$_{t-3}$	1.25 (2.4)*	1.07 (1.4)	0.94 (1.2)
%ΔS&P Index$_{t-3}$	−0.19 (0.7)	−0.55 (2.2)*	0.13 (0.3)
Real Rates$_{t-3}$	2.16 (2.7)**	2.74 (3.1)**	0.12 (0.1)
NYC Zoning Bonus$_{t-2}$	13.8 (1.2)		9.88 (0.6)
NYC Tax Abatement$_{t-2}$	12.0 (0.6)		28.6 (1.9)
NYC ICIP$_{t-2}$	−2.5 (0.1)		43.2 (1.9)
NYC Zoning 1916 Dummy$_{t-2}$	−49.2 (2.1)*		−61.8 (2.1)*
NYC Zoning 1961 Dummy$_{t-2}$	−45.0 (1.3)		−105.9 (2.3)*
Chi Zoning 130$_{t-2}$	−38.9 (2.3)*	−10.0 (0.6)	
Chi Zoning 260$_{t-2}$	−48.2 (1.8)	−18.2 (0.5)	
Chi Zoning 200$_{t-2}$	−90.9 (2.5)*	−45.1 (0.8)	
Chi Zoning 260/400$_{t-2}$	−89.2 (1.5)	−12.6 (0.2)	
Chi Zoning 264+tower$_{t-2}$	−102.2 (2.3)*	−49.5 (0.6)	
Chi Zoning plot×144$_{t-2}$	−115.6 (2.7)**	−105.1 (1.1)	
Chi Zoning FAR$_{t-2}$	−115.7 (2.2)*	−82.1 (0.8)	
Chicago Dummy	190.8 (2.8)**		
ln(Plot Size)	12.3 (6.4)**	11.1 (5.1)**	29.0 (4.2)**
Constant	−4076.6 (3.9)**	−2461.1 (1.3)	−10044 (4.4)**
Observations	227	113	114
R^2	0.62	0.67	0.63
$\bar{R}^2$	0.58	0.62	0.57
Durbin Watson		1.48	1.57

Table 6: Regression Results for Height of Tallest Building (in levels), 1885-2007. *Stat. Sig. at 95% level; **Stat. Sig. at 99% level. See Appendex for sources.

Variable	Count	Height
ln(RGDP Detrend)$_{t-2}$	0.03	0.04
ln(F.I.R.E.)$_{t-2}$	0.95	0.84
ln(Total Stock)$_{t-2}$	0.00	0.00
ln(Materials Costs)$_{t-2}$	0.00	0.20
ln(Stock Volume)$_{t-2}$	0.00	0.00
ln(Metro Pop)$_{t-2}$	0.00	0.04
%ΔRE Loans$_{t-3}$	0.28	0.89
%ΔS&P Index$_{t-3}$	0.03	0.13
Real Rates$_{t-3}$	0.21	0.14
ln(Plot Size)	0.21	0.01

Table 7: Results of chi-squared tests on the equality of coefficients. p-values are given for null hypothesis that the coefficients for the two cities are equal. The first column is from Table 5, equations (2) and (4). The second column is from Table 6, equations (2) and (3).

	(SUR 1)	(SUR 2)	(SUR 1)	(SUR 2)
	Chicago	Chicago	NYC	NYC
ln(RGDP Detrend)$_{t-2}$	1.871 (2.68)**	1.176 (1.79)	0.432 (0.74)	0.342 (0.62)
ln(F.I.R.E.)$_{t-2}$	1.004 (1.67)	0.559 (1.01)	1.114 (2.61)**	0.93 (2.29)*
ln(Total Stock)$_{t-2}$	−0.671 (3.59)**	−0.429 (2.44)*	−2.049 (6.74)**	−1.651 (5.09)**
ln(Materials Costs)$_{t-2}$	−1.619 (2.67)**	−0.672 (1.18)	−3.75 (7.34)**	−3.069 (5.73)**
ln(Stock Volume)$_{t-2}$	0.034 (0.71)	0.027 (0.61)	0.238 (4.53)**	0.187 (3.54)**
ln(Metro Pop)$_{t-2}$	2.231 (2.39)*	1.337 (1.54)	9.027 (7.19)**	7.192 (5.25)**
%ΔRE Loans$_{t-3}$	0.016 (2.56)*	0.009 (1.65)	0.022 (3.78)**	0.019 (3.30)**
%ΔS&P Index$_{t-3}$	0.001 (0.27)	0.00 (0.17)	0.007 (3.19)**	0.007 (3.16)**
Real Rates$_{t-3}$	0.019 (1.95)	0.012 (1.29)	0.004 (0.41)	−0.002 (0.17)
NYC Zoning Bonus$_{t-2}$			0.492 (2.51)*	0.395 (2.06)*
NYC Tax Abatement$_{t-2}$			0.512 (3.60)**	0.418 (2.98)**
NYC ICIP$_{t-2}$			0.488 (2.52)*	0.395 (2.07)*
NYC Zoning 1916 Dummy$_{t-2}$			−0.191 (0.69)	0.156 (0.58)
NYC Zoning 1961 Dummy$_{t-2}$			−0.506 (1.3)	−0.407 (1.09)
Chi Zoning 130$_{t-2}$	−0.204 (0.47)	−0.148 (0.37)		
Chi Zoning 260$_{t-2}$	−0.243 (0.44)	−0.277 (0.56)		
Chi Zoning 200$_{t-2}$	−0.455 (0.68)	−0.374 (0.61)		
Chi Zoning 260/400$_{t-2}$	−0.549 (0.68)	−0.367 (0.5)		
Chi Zoning 264+tower$_{t-2}$	0.132 (0.15)	0.069 (0.09)		
Chi Zoning plot×144$_{t-2}$	−0.194 (0.2)	−0.164 (0.18)		
Chi Zoning FAR$_{t-2}$	0.343 (0.3)	0.083 (0.08)		
ln(Plot Size)	0.089 (9.02)**	0.086 (9.26)**	0.079 (7.21)**	0.078 (7.31)**
ln(1+count)$_{t-1}$		0.283 (4.86)**		0.207 (3.47)**
Constant	−33.148 (2.48)*	−19.825 (1.58)	−139.725 (7.28)**	−111.381 (5.32)**
Observations	113	113	113	113
R^2	0.8455	0.8778	0.8442	0.8630

Table 8: Seemingly unrelated regression results for ln(1+count). Absolute value of z statistics in parentheses. * significant at 5%; ** significant at 1%.

	(SUR 1)	(SUR 2)	(SUR 1)	(SUR 2)
	Chicago	Chicago	NYC	NYC
ln(RGDP Detrend)$_{t-2}$	277.317	213.77	67.177	72.692
	(3.32)**	(2.57)*	(1.01)	(1.17)
ln(F.I.R.E.)$_{t-2}$	107.691	49.373	78.561	44.118
	(1.45)	(0.67)	(1.64)	(0.98)
ln(Total Stock)$_{t-2}$	−0.186	14.03	−123.566	−87.173
	(0.01)	0.63	(3.71)**	(2.72)**
ln(Materials Costs)$_{t-2}$	−132.46	−106.439	−288.309	−182.128
	(1.8)	(1.5)	(5.03)**	(3.16)**
ln(Stock Volume)$_{t-2}$	−8.503	−7.876	18.253	13.679
	(1.45)	(1.4)	(3.12)**	(2.48)*
ln(Metro Pop)$_{t-2}$	150.124	71.138	594.402	398.196
	(1.31)	0.63	(4.27)**	(2.92)**
%ΔRE Loans$_{t-3}$	1.188	0.65	0.942	0.702
	(1.62)	(0.9)	(1.44)	1.15
%ΔS&P Index$_{t-3}$	−0.5	−0.518	0.123	0.03
	(1.72)	(1.86)	(0.47)	(0.12)
Real Rates$_{t-3}$	2.749	2.045	0.56	0.447
	(2.34)*	(1.77)	(0.45)	0.39
NYC Zoning Bonus$_{t-2}$			10.628	10.628
			(0.47)	(0.51)
NYC Tax Abatement$_{t-2}$			31.09	13.583
			(1.9)	(0.87)
NYC ICIP$_{t-2}$			37.282	30.879
			(1.69)	(1.5)
NYC Zoning 1916 Dummy$_{t-2}$			−60.801	−27.394
			1.94	(0.92)
NYC Zoning 1961 Dummy$_{t-2}$			−103.617	−64.227
			(2.37)*	(1.56)
Chi Zoning 130$_{t-2}$	−9.358	−2.719		
	(0.18)	0.05		
Chi Zoning 260$_{t-2}$	−13.064	−0.336		
	(0.2)	(0.01)		
Chi Zoning 200$_{t-2}$	−45.442	−14.97		
	(0.55)	(0.19)		
Chi Zoning 260/400$_{t-2}$	−6.947	40.572		
	(0.07)	(0.42)		
Chi Zoning plot×144$_{t-2}$	−50.242	−3.398		
	(0.47)	(0.03)		
Chi Zoning plot×144$_{t-2}$	−94.759	−30.673		
	(0.78)	(0.26)		
Chi Zoning FAR$_{t-2}$	−70.258	−8.272		
	(0.49)	(0.06)		
ln(Plot Size)	10.684	10.965	26.183	21.13
	(6.32)**	(6.71)**	(5.95)**	(4.92)**
Max$_{t-1}$		0.23		0.375
		(3.15)**		(5.15)**
Constant	−2,289.16	−1,123.16	−9,406.42	−6,342.41
	(1.39)	(0.7)	(4.45)**	(3.05)**
Observations	113	113	113	113
R^2	0.6735	0.6982	0.6230	0.6712

Table 9: Seemingly unrelated regression results for max height. Absolute value of z statistics in parentheses. * significant at 5%; ** significant at 1%.

		NYC ln(1+count)	NYC max
(SUR 1)	Chi (1+count)	0.2835	0.1215
(SUR 2)	Chi (1+count)	0.1953	0.0812
(SUR 1)	Chi max	0.1295	-0.0341
(SUR 2)	Chi max	0.1108	-0.1239

Table 10: Correlations of residuals from SU regressions. (1) are from regressions without a lag dep. var. (2) are from regressions with a lag dependent variable.

Variable	Mean	Std. Dev.	Min	Max	Obs
NYC ln(1+count)	0.00	0.38	-0.87	0.80	114
Chi (1+count)	0.00	0.36	-1.04	0.67	113
NYC max	0.73	42.6	-173.2	131.4	114
Chi max	0.00	45.1	-109.1	193.1	113

Table 11: Descriptive statistics for residuals from SU regressions with lagged dependent variables.

	(1) NYC ln(1+count)	(2) Chicago ln(1+count)	(3) NYC max	(4) Chicago max^{a}
Chi ln(1+count)$_t$	0.20 (2.2)*		13.9 (1.2)	65.1 (6.0)**
Chi max$_t$		0.004 (6.0)**	-0.21 (2.3)*	
Chi max$_{t-1}$	0.002 (2.4)*		-0.15 (1.8)	
NYC ln(1+count)$_t$		0.13 (1.5)	46.1 (4.6)**	
NYCln(1+count)$_{t-1}$		0.19 (2.3)*	11.2 (1.2)	-25.1 (1.9)
NYC max$_t$	0.003 (4.4)**	0.001 (1.2)		-0.18 (1.7)
NYC max$_{t-1}$		-0.002 (2.7)**		0.31 (2.2)*
Constant	0.00 (0.02)	0.00 (0.0)	0.17 (0.05)	-0.01 (0.0)
Observations	112	112	112	112
R^2	0.23	0.31	0.22	0.32
$\bar{R}^2$	0.21	0.28	0.19	0.29

Table 12: All variables are residuals from SUR 2. t-statistics below estimates (robust t-statistics given for equation (4)). * Stat. sig. at 1%; ** Stat. sig. at 5%.