The economics of skyscrapers

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Outline

1. Introduction
2. A model of building height
3. Building height and office rents
4. Building height regulation
5. Summary
1. Introduction

- **Covered topics**
  - Why do cities exist?
  - Agglomeration economies
  - Urban growth and city size
  - Land rent and urban structure
  - Housing and housing policies
  - The economics of urban planning

- **Today**
  - Skyscrapers!
  - Exam!
<table>
<thead>
<tr>
<th>Building</th>
<th>City</th>
<th>Year</th>
<th>Height</th>
</tr>
</thead>
<tbody>
<tr>
<td>Burj Khalifa</td>
<td>Dubai</td>
<td>2010</td>
<td>828 m</td>
</tr>
<tr>
<td>Taipei 101</td>
<td>Taipei</td>
<td>2004</td>
<td>503 m</td>
</tr>
<tr>
<td>Shanghai Financial Centre</td>
<td>Shanghai</td>
<td>2008</td>
<td>492 m</td>
</tr>
<tr>
<td>Intern. Commerce Centre</td>
<td>Hong Kong</td>
<td>2010</td>
<td>484 m</td>
</tr>
<tr>
<td>Petronas Towers</td>
<td>Kuala Lumpur</td>
<td>1998</td>
<td>452 m</td>
</tr>
<tr>
<td>Nanjing Financial Complex</td>
<td>Nanjing</td>
<td>2010</td>
<td>450 m</td>
</tr>
<tr>
<td>Willis Tower</td>
<td>Chicago</td>
<td>1974</td>
<td>442 m</td>
</tr>
</tbody>
</table>
1. Introduction

- **Absolute winner: Burj Kalifa ➔ 828 m**

- 9 out of 10 buildings are constructed in the last 10 years
1. Introduction

- In Sri Lanka, there are relatively few tall buildings yet

World trace centre, 152m
Colombo in 10 years:

<table>
<thead>
<tr>
<th>#</th>
<th>Name</th>
<th>Status</th>
<th>Height (in m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Krrish Square Tower</td>
<td>Proposed</td>
<td>420</td>
</tr>
<tr>
<td>2</td>
<td>Diamond Towers</td>
<td>Proposed</td>
<td>246</td>
</tr>
<tr>
<td>3</td>
<td>Indocean Developers</td>
<td>Under construction</td>
<td>240</td>
</tr>
<tr>
<td>4</td>
<td>Celestial Residences</td>
<td>Under construction</td>
<td>158</td>
</tr>
<tr>
<td>5</td>
<td>World Trade Centre</td>
<td>Built</td>
<td>152</td>
</tr>
<tr>
<td>6</td>
<td>The Dawson Grand Tower</td>
<td>Under construction</td>
<td>133</td>
</tr>
<tr>
<td>7</td>
<td>Hilton Tower</td>
<td>Built</td>
<td>129</td>
</tr>
<tr>
<td>8</td>
<td>The Emperor</td>
<td>Built</td>
<td>123</td>
</tr>
<tr>
<td>9</td>
<td>Crescat Office &amp; Condominium</td>
<td>Built</td>
<td>113</td>
</tr>
<tr>
<td>10</td>
<td>110 Parliament Road</td>
<td>Proposed</td>
<td>100</td>
</tr>
</tbody>
</table>

- Skyscraper construction seems to be booming.

But why should we want to construct tall buildings anyway?
1. Introduction

- Monocentric city model learns us that building height should be generally decreasing in distance to the city centre

- In more expensive locations firms and households economise on property size

- Higher rents imply higher buildings
  - Until $MC_{floor}=MB_{floor}$
1. Introduction

- In general we observe indeed that building heights are decreasing in distance to the city centre
  - Example for the Netherlands
1. Introduction

- This does not explain presence of skyscrapers

- In this lecture we investigate other reasons why buildings may be tall
  - Increasing returns to building height
  - Landmark effect

- In almost all cities, building height is strongly restricted
  - We investigate why this is the case and whether it makes sense
1. Introduction

- Goals of today’s class
  - Learn about urban patterns that deviate from monocentric city model
  - Learn about the *raison d’etre* of skyscrapers
  - Understand why building height regulations exist and whether these make sense from an economic point of view
  - Learn to interpret econometric outcomes and discuss issues of causality
2. A model of building height

1. Introduction
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3. Building height and office rents
4. Building height regulation
5. Summary
2. A model of building height

- Recap of monocentric city model
  - What will happen with rents when people live further away from the CBD?
  - Are houses in the suburbs smaller or larger than in the CBD?
2. A model of building height

- Land rent is a *decreasing* function of distance to the city centre

![Graph showing the relationship between rent and distance to the CBD]

- *Residential use*
- *Agricultural use*

Distance to the CBD

Rent

- households
- agriculture

\[ \alpha = 0.8, \gamma = 200, \delta = 50, t = 10, p^A = 10 \]
Now assume a profit maximising firm and a perfectly competitive market.

The profits per floor are then:

\[ \pi = q(d) - r(d) \]

where \( \pi \) are profits.

- \( q(d) \) is the productivity at distance \( d \) from the CBD.
- \( r \) is the rent per floor.

Assume that \( q(d) = A - bd \), define the rent function.
Now assume a construction firm that aims to maximise profits:

\[ \Pi = rh - c(h) \]

where \( h \) is the number of floors

\( c(h) \) are the construction costs

Assume that \( c(h) = ch^2 \), define the optimal building height
2. A model of building height

- The optimal building height is given by:
  \[ h^* = \frac{r(d)}{2c} \]

Q How is the optimal building height related to
  - The distance to the CBD
  - The construction cost parameter \( c \)
2. A model of building height

- However, not all buildings in the city centre are about the same height
- We also observe tall buildings outside the city centre and low buildings in the city centre

Could you think of any reasons why?
2. A model of building height

- Not all buildings in the city centre have about the same height
  - Land use planning and height restrictions
  - Durability of buildings
  - But also: (extremely) tall buildings may offer additional amenities to tenants
2. A model of building height

- Tall buildings may offer additional *amenities* to tenants
  - *Within-building* agglomeration economies
  - Landmark effect
  - View effect
2. A model of building height

Within-building agglomeration effect

- This implies that firms in taller buildings are more efficient

- Internal returns to scale
  - Larger firms are more efficient
  - Room for expansion

- External returns to scale
  - Deal-making/face-to-face contacts with clients and competitors
  - For example, WTC at south-axis

"WTC Amsterdam is a dynamic commercial 'world city', populated by at least three hundred companies, which often are internationally oriented." (www.wtcamsterdam.nl)
Within-building agglomeration effect

- Agglomeration economies are likely diminishing
  - An additional meter increase in building height is more important for low buildings than for tall buildings
2. A model of building height

Landmark effect

- Firms gain attention by locating in well-known building
  - Easier to attract clients
  - Reputation effect

- Landmark effect is relative effect that is only relevant for the tallest building(s)

View effect

- Tall buildings offer nice views to workers
2. A model of building height

- Let’s formalise this. The profit of a firm locating in a building may be given as follows:

\[ \pi = q(h, d) + \nu(h^{\text{max}}) - r \]

- With zero profits, it holds that:

\[ r = q(h, d) + \nu(h^{\text{max}}) \]

Assume that \( q(h, d) = A - bd + \alpha h \). Derive the optimal building height.

**HINT:** Recall that the optimal building height was given by

\[ h^* = \frac{r(d)}{2c} \]
2. A model of building height

- In the paper we aim to know more about the following relationship:

  \[ \text{building height} \uparrow \rightarrow \text{rents} \uparrow \]

  - To learn more about
    1. within-building agglomeration economies
    2. landmark effect
    3. view effect

- We control for the competing explanation

  \[ \text{rents} \uparrow \rightarrow \text{building height} \uparrow \]
3. Building height and office rents

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3. Building height and office rents

- Hypotheses
  1. Taller buildings command higher rents because of within-building agglomeration economies
  2. The tallest building(s) command higher rents because of a landmark effect

We will also test for a view effect...
3. Building height and office rents

- We employ a ‘hedonic price’ framework

- So, price is a function of building height

  \[ \log r_i = \alpha h_i + \xi_i \]

Q: How to interpret \( \alpha \)?
3. Building height and office rents

- Reverse causality and omitted variable bias
  - Taller buildings are located on attractive locations with higher rents (e.g. CBD)
  - Taller buildings are of higher quality

- This implies that $\alpha$ does not measure a causal impact of building height on office rents
  - As economists we are mainly interested in causal effects

Q What is the difference between a correlation and a causal effect
3. Building height and office rents

- We therefore include
  - Control variables (e.g. construction year)
  - Postcode dummies

- So, price is a function of building height and many control variables
  \[ \log r_i = \alpha h_i + \beta x_i + \xi_i, \]

- In the paper, we also use instrumental variables to establish causality
  - ... difficult to explain now
3. Building height and office rents

- We also expect that building height has a nonlinear effect on rents
  - Within-building agglomeration economies become less important (*diminishing*)
  - Landmark effect is only important for tallest building(s)

- We therefore estimate a nonparametric regression:
  \[ \log r_i = \Omega(h_i) + \beta x_i + \xi_i \]
- Nonparametric: let the data decide what the functional form is
3. Building height and office rents

- Analysis of three Dutch cities: Amsterdam, Rotterdam and Utrecht
- Unique dataset with office transactions
- 4,792 transactions
- We control for a wide range of attributes (e.g. Construction Year)
- We also include 145 postcode dummies
Is the Sky the Limit?

Outline

1. Introduction
2. Theory
3. Empirical Methodology
4. Results
5. Summary

Empirical Methodology

Amsterdam
Utrecht

City centre
3. Building height and office rents

- Some descriptives
  - Rents — €143 per m²
  - Average building height — 21 meters
  - 4% of observations in buildings taller than 80m
  - A floor is about 3.8 meters
3. Building height and office rents

- Results

<table>
<thead>
<tr>
<th>TABLE 1 — REGRESSION RESULTS OF THE EFFECT OF BUILDING HEIGHT ON OFFICE RENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>(dependent variable: logarithm of rent per square meter)</td>
</tr>
<tr>
<td>(1) OLS</td>
</tr>
<tr>
<td>Building height (in 10m)</td>
</tr>
<tr>
<td>0.030 (0.002)***</td>
</tr>
<tr>
<td>Control variables</td>
</tr>
<tr>
<td>Yes</td>
</tr>
<tr>
<td>Number of observations</td>
</tr>
<tr>
<td>4,792</td>
</tr>
<tr>
<td>( R^2 )</td>
</tr>
<tr>
<td>0.702</td>
</tr>
</tbody>
</table>

Notes: Standard errors are between parentheses.

- ** Significant at the 1 percent level
- *** Significant at the 1 percent level
- ** Significant at the 5 percent level
- * Significant at the 10 percent level

Q How to interpret these results?
3. Building height and office rents

- **Results**

  **TABLE 1 — Regression results of the effect of building height on office rents**

<table>
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  **Notes:** Standard errors are between parentheses.
  
  *** Significant at the 1 percent level
  **  Significant at the 5 percent level
  *   Significant at the 10 percent level

- 10 meters increase in building height leads to an increase in office rents of 3%
- The effect is statistically significant
- With the control variables included, the model explains 70% of the variation in office rents
3. Building height and office rents

- If we plot the marginal effects

- Landmark effects seems to become important after 100 meters

- Landmark 3-5% for a building of 130 meters
3. Building height and office rents

- So, taller buildings seem to command much higher rents
- Interpretation
  - Within-building agglomeration economies
  - Landmark effect
- Other interpretations
  - Quality (*but* we control for building quality)
  - View (*seems not important*)
4. Building height regulation

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4. Building height regulation

- We observe building heights regulations in almost all cities in the world

What may be a good reason to implement building height regulations?
4. Building height regulation

- We observe building heights regulations in almost all cities in the world

- Negative externalities
  - Protect historic districts
  - Airports
  - External effect of building itself (blocked view, shadow, wind)
  - Traffic congestion

- Positive externalities as well
  - Shorter commuter distances
  - Agglomeration economies!
4. Building height regulation

- Examples of building height regulations

- Utrecht
  - No building taller than the Dom tower (112 meter)
  - No buildings twice the average height in the neighbourhood
4. Building height regulation

- Examples of building height regulations

- London
  - Protect views to St. Paul’s Cathedral
  - Protect historic city centre

- Many other cities
  - Floor-to-area restrictions
  - For a given building size, a minimum lot size is required
As argued previously, the marginal benefits of adding an additional floor should equal the marginal costs (see page 187, O’Sullivan)
Now assume that height is restricted so that \( h^R < h^* \)

**Q** What is the deadweight loss?
4. Building height regulation

- Now assume that height is restricted so that \( h^R < h^* \)

![Diagram showing marginal costs and marginal benefits with deadweight loss](image-url)
However, the social costs may be \textit{above} the marginal costs of construction.

\textbf{Q} Why?
However, the social costs may be also below the marginal costs of construction.

Why?
So, the question is whether building height regulations are indeed welfare optimising.

This is hard to investigate:
- Hard to quantify the total external effects
- Positive externalities are usually ignored
4. Building height regulation

- Glaeser, Gyourko and Saks (2005)
  - New York housing market
  - Changes in demand have not led to increases in supply due to restrictions
  - Prices >> marginal costs of adding a floor in a number of US housing markets

Q Why is the difference between price and marginal construction costs an indicator of regulatory restrictiveness?
4. Building height regulation

- Glaeser, Gyourko and Saks (2005)
  - E.g. for the Manhattan housing market

![Figure 1: Housing Permits in Manhattan and Prices](image-url)

(Four-year moving averages)

- Manhattan permits, units
- Real housing prices

**Figure 1: Housing Permits in Manhattan and Prices**

<table>
<thead>
<tr>
<th>Year</th>
<th>Manhattan permits, units</th>
<th>Real housing prices</th>
</tr>
</thead>
<tbody>
<tr>
<td>1950</td>
<td>1000</td>
<td>0.6</td>
</tr>
<tr>
<td>1960</td>
<td>2000</td>
<td>0.7</td>
</tr>
<tr>
<td>1970</td>
<td>3000</td>
<td>0.8</td>
</tr>
<tr>
<td>1980</td>
<td>4000</td>
<td>0.9</td>
</tr>
<tr>
<td>1990</td>
<td>5000</td>
<td>1.0</td>
</tr>
<tr>
<td>2000</td>
<td>6000</td>
<td>1.0</td>
</tr>
</tbody>
</table>
Glaeser, Gyourko and Saks (2005)

- They try to estimate the approximate magnitude of externalities (blocked views, congestion, fiscal externalities)
- They find that the externalities are too small to explain the large difference between the price and the marginal construction costs
4. Building height regulation

- Cheshire and Hilber (2008)
  - Estimate the ratio price-marginal construction costs for the Europe office

<table>
<thead>
<tr>
<th></th>
<th>Regulatory Tax</th>
</tr>
</thead>
<tbody>
<tr>
<td>London – West End</td>
<td>9.37</td>
</tr>
<tr>
<td>London – City</td>
<td>5.31</td>
</tr>
<tr>
<td>Milan</td>
<td>5.11</td>
</tr>
<tr>
<td>Paris – City</td>
<td>4.75</td>
</tr>
<tr>
<td>Frankfurt</td>
<td>4.31</td>
</tr>
<tr>
<td>Paris – La Défense</td>
<td>2.93</td>
</tr>
<tr>
<td>Amsterdam</td>
<td>2.92</td>
</tr>
<tr>
<td>Brussels</td>
<td>1.84</td>
</tr>
<tr>
<td>New York – Manhattan</td>
<td>1.50</td>
</tr>
</tbody>
</table>
4. Building height regulation

- Cheshire and Hilber (2008)
  - They also cannot justify these restrictions from an externalities point of view

- Suggestive evidence that building height regulations are welfare decreasing
  - But preliminary evidence
  - More research to the magnitude of externalities is needed
5. Summary

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5. Summary

- What may be other for tall buildings than economising on land rents?
- Why are some buildings extremely tall?
- What is the idea behind building height regulations?
- Why may building height regulations welfare decreasing?
5. Summary

Questions?

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See also [www.urban economics.nl](http://www.urban economics.nl) for lecture sheets and links to papers
5. Summary

Literature


O’Sullivan, pp. 186-189

Further reading
