The Value of Design in Asset Pricing

Rong, Yang, Kang and Chegut
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Measuring the Financial Impact of Architectural Design Features

with Helena H Rong, MIT
Juncheng Yang, MIT
Minkoo Kang, MIT
and Dr. Andrea Chegut, MIT

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Minkoo Kang is a Lecturer at the MIT SAP and a Researcher at the MIT REI Lab. He studies the financial impact of design.

Dr. Andrea Chegut is the Director of the REI Lab and studies the value of design and technology for commercial real estate.

Rong, Yang, Kang and Chegut
Disciplinary Challenge

Design, Resiliency and Sustainability are currently left out of the narrative of capitalism.

**Why**

- Two domains (finance and design) that are at odds with one another, with good reason, but at societies detriment. As we need, sustainable, healthy, resilient, just and equitable buildings for our communities.
- The lack of feedback and miscommunication between real estate valuation and building design often to poor design and economic outcomes.
- Design strategies that surround resiliency, sustainability, health and wellness are not put forth with financial evidence.
- Data (details from stories) have not been shared or collected in a systematic way about these strategies.
- Design pedagogy and process do not align with a pecuniary approach to measuring what architecture and urban design turns into in the financial system - institutional and corporate real estate.
- Finally, there is limited measurement of sustainability, resiliency, health, etc. of buildings to even begin to fit into the levers and gears that move the financial markets.
How Finance Sees Design

Current valuation methods only consider the crudest elements of physical building features such as size, number of story, and age.

- To execute pricing models, real estate asset pricing modelers consider the following as dependent variables for driving asset valuation: building size, age, number of stories, status of renovation, location and proximity to CBD, all of which describe only the crudest elements of a building that have already been specified as guidelines prior to the design of the physical structure.
Financial valuation considers involvement of awarded architects as measure of design

• Value of design in real estate becomes increasingly important
• In recent literature, real estate perceives and measures value of design through measuring involvement of awarded architects. However, this only measures the value of having awarded architects, not specifically what architects do - the physical forms they bring to their designs

The Value of Awarded Design in Real Estate Asset Pricing

About the Project

Researchers identified 55 buildings in Manhattan and 80 transactions were observed. Within the 80 transactions, 4 firms have more than 2 awards from various prestigious awards. Awarded architects bring to their designs the architectural design solutions. The Value of Awarded Design in Real Estate Asset Pricing is an important feature of the built environment.

In order to understand the effect of the awarded architects on the price, we matched each of the awarded buildings in this sample to nearby commercial buildings in the similar location using the Geographic Information System (GIS).

To measure financial performance, I use several datasets, Real Estate Analytics (REA), Capital Analytics, Compstak, Walkscore and NYC public data. When controlling for location and transaction features, the result of the hedonic analysis suggests that buildings designed by awarded architects/firms are associated with a 25% premium over buildings that are designed by non-awarded architects.

How Finance Sees Design

How Finance Sees Design

Award Criteria

A total of 18 awarded architects/firms have designed 55 buildings in Manhattan, and 80 transactions were observed. Within the 80 transactions, 4 firms have more than 2 awards from various prestigious awards. Awarded architects bring to their designs the architectural design solutions.

Control Group Data

In order to understand the effect of the awarded architects on the price, we matched each of the awarded buildings in this sample to nearby commercial buildings in the similar location using the Geographic Information System (GIS).

Legend

About the Researchers

Dr. Andrea Chegut is a research scientist at MIT’s SA+P, Center for Real Estate that works with public and private data. She wants to understand how financial performance of the built environment.

About the Lab

The MIT Real Estate Innovation Lab is an R&D lab at the Department of Architecture and Urbanism at the Sloan School of Management. The Lab is a research and development lab that focuses on how innovation in the built environment.

About the Project

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Table: Awarded Architects and Firms

<table>
<thead>
<tr>
<th>Awarded Architects &amp; Firms</th>
<th>1990s (9)</th>
<th>2000s (12)</th>
<th>2010s (15)</th>
<th>Total (36)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Awarded Architects</td>
<td>1990s (9)</td>
<td>2000s (12)</td>
<td>2010s (15)</td>
<td>Total (36)</td>
</tr>
<tr>
<td>Pritzker Prize</td>
<td>1990s (9)</td>
<td>2000s (12)</td>
<td>2010s (15)</td>
<td>Total (36)</td>
</tr>
<tr>
<td>National Design Award</td>
<td>1990s (9)</td>
<td>2000s (12)</td>
<td>2010s (15)</td>
<td>Total (36)</td>
</tr>
<tr>
<td>AIA Architecture Firm Award</td>
<td>1990s (9)</td>
<td>2000s (12)</td>
<td>2010s (15)</td>
<td>Total (36)</td>
</tr>
</tbody>
</table>
Design and sustainability should have a bearing in every building’s outcomes due to the high value proposition that it brings.

Practicing architects are confronted with defending the value of both functional and aesthetic building needs, such as daylight, views, materiality and spatial contextuality.

How can we begin to collect and measure these qualitative attributes design brings?
Motivation
Omitting design features from asset valuation leaves a missed opportunity to understand the extent to which the actual design and function of a building impact the market value of a property during individual real estate transactions, thereby diminishing the agency of design during negotiation processes.

- It is also imperative to further develop a systematic approach to recognize and describe design attributes to facilitate the communication among designers and researchers when discussing about forms and styles of design works.
- Enhanced methods may also potentially address the difficulty of interpreting the current research results by isolating individual design attributes or removing confounding factors.
The Value of Design in Asset Pricing

Existing Literature

There is limited literature that focuses on the financial valuation of architectural design features. How does design designate features or components of design?

**DESIGN LITERATURE**

- In the design literature, scholars look at how design designates features or components of design, and begin to break down a building into measurable features. Francis Ching and Rem Koolhaas are some of the scholars who examine features of buildings and design and what makes up componentry. Koolhaas' Elements of Architecture analysed the fundamentals of architecture with an emphasis on tectonics by dissecting architecture into fifteen primary components. These studies understood architecture as integration of tangible and intangible elements that are related to materiality and historical meanings. However, their research never tied back to financial value.

**Rem Koolhaas: Elements of Architecture**

**Francis Ching: A Visual Dictionary of Architecture**

**Francis Ching: Form, Space and Order**
Can we quantify design features? If so, with what metrics?

Design Features Inventory

We brainstormed and identified 22 design features as quantifiable features which we can collect and evaluate to construct correlations between design and real estate market value.

- **Iconicity**: measures the recognizability of a built structure and its cultural impacts
- **Consistency and variations**: measures how different a building is from its surroundings
- **Literal greens**: quantifies the percentage of vegetation and green surfaces
- **Non-90 degree angles**: quantifies the non-orthogonal moments in a building
- **Public-to-private ratio**: measures the amount of public space within a building
- **Spatial flexibility**: measures how adaptive and transformable are the spaces
- **Materiality**: measures both interior and exterior use of materials
- **Setbacks**: a dummy variable which checks whether a building has a terrace-like form towards its upper portion

1. **ICONICITY**
   - [Image 50x57 to 83x74] Zaha Hadid Architects
   - 520 W28 St, New York by Zaha Hadid Architects

2. **CONSISTENCY AND VARIATION**
   - [Image 379x308 to 562x445] Streets of Amsterdam
   - 1000 Trees by Sou Fujimoto, Paris

3. **LITERAL GREENS**
   - [Image 592x308 to 775x445] Jewish Museum by Daniel Libeskind, Berlin
   - 500 Fifth Avenue, New York City

4. **NON-90 DEGREE ANGLES**
   - [Image 1019x308 to 1202x444] The Plaza at Santa Monica by OMA
   - 500 Fifth Avenue, New York City

5. **PUBLIC-TO-PRIVATE RATIO**
   - [Image 805x308 to 988x445] Timmerhuis by OMA, Rotterdam
   - 1007 Trees by Sou Fujimoto, Paris

6. **SPATIAL FLEXIBILITY**
   - [Image 379x78 to 562x217] The Plaza at Santa Monica by OMA
   - Cooper Union by Morphosis, New York City

7. **MATERIALITY**
   - [Image 806x79 to 989x217] 500 Fifth Avenue, New York City
   - 500 Fifth Avenue, New York City

8. **SETBACKS**
   - [Image 1020x78 to 1199x216] 520 W28 St, New York by Zaha Hadid Architects
   - The Plaza at Santa Monica by OMA

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Can we quantify design features? If so, with what metrics?

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We brainstormed and identified 22 design features as quantifiable features which we can collect and evaluate to construct correlations between design and real estate market value.

- Size of the lobby: measures how grand is an entrance
- Interior design: a dummy variable which checks whether a reputable interior designer is onboard with the project
- Podium extrusion: a dummy variable which checks whether a tower has a horizontal base
- Double or triple height spaces: measures the amount of "tall spaces" of a building
- Number of interior walls: measures the openness of a space
- Curvature: whether a building has a curve in plan, section or elevation
- Adaptive reuse buildings: a dummy variable which checks whether a building has had a previous programmatic identity
- Number of staircases (non-fire-stairs): measures the usage of staircases as an expression of design

9. SIZE OF LOBBY

10. INTERIOR DESIGN

11. PODIUM EXTRUSION

12. DOUBLE/TRIPLE HEIGHT SPACES

13. NUMBER OF INTERIOR WALLS

14. CURVATURE

15. ADAPTIVE RE-USE BUILDINGS

16. NUMBER OF STAIRCASES

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Can we quantify design features? If so, with what metrics?

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**Design Features Inventory**

We brainstormed and identified 22 design features as quantifiable features which we can collect and evaluate to construct correlations between design and real estate market value.

- **Diagonal vs. grid**: measures whether urban form impacts the market value
- **Daylight**: quantifies the amount of daylight each space receives
- **Views**: quantifies the contents of a view
- **Levels of customization**: assess how similar a building is to itself (the degree to which customized parts are used)
- **Solid/void ratio**: measures how articulated a building is by calculating surface to volume ratio
- **Balconies**: measures connection to the exterior
Selected Features:

- **Diagonal vs. grid**: measures whether urban form impacts the market value
- **Curvature**: whether a building has a curve in plan, section or elevation
- **Setbacks**: a dummy variable which checks whether a building has a terrace-like form towards its upper portion
- **Podium extrusion**: a dummy variable which checks whether a tower has a horizontal base
Study feature: 01) Diagonality

Do commercial buildings located on diagonal intersections receive a premium bonus during transaction?

Buildings located on diagonal roads and intersections. Given that Manhattan uses an extensive urban grid to organize its urban space, most building sites are contained within rectangular blocks. Hence, building sites along diagonal roads are usually non-rectangular. Since land value is so high in Manhattan so that most build developments would tend to maximize building footprint by occupying as much site area as possible. In that sense, buildings on diagonal intersections would usually have a unique geometry due to the rather irregular shape of site.

- Commissioners Plan of 1811 imposed a rigid gridiron plan on the island of Manhattan, whose proponents saw as "legible, accessible, efficient, traditional, and perhaps, even egalitarian".
- The legacy of the grid vs. diagonal tension produces a major public open space approximately every ten blocks. Whenever Broadway crosses an Avenue, it creates a large six-way "bowtie" intersection, generously providing room for public space such as parks or seating areas around the buildings, thereby enhancing safety, pedestrian traffic and liveliness.
Study feature: 02) Curvature

Do commercial buildings with a curve in either plan or elevation receive a premium bonus during transaction?

Buildings with a curved feature in either plan or elevation. Curved features, especially large-scale features, might require special design of structural system and increase the budget. However, curved features “… can be more vigorous and expressive in nature. Their shapes change dramatically as we view them from different perspectives” (Ching, 1971:43).

- In general, the way curvilinearity affects human perception has been studied widely across scales in the built environment: from products’ graphics and container designs, to cars, to architectural interiors.
- Conclusive to all these studies which derive from various disciplines, people prefer curved-contoured objects for its sense of pleasantness and harmony. These studies suggest curvature found in the built environment are design choices with a tangible impact on peoples’ preferences and choices in consumer and social contexts, and therefore deserve more careful examination of its value.
Study feature: 03) Setbacks
Do building setbacks affect transaction price for commercial buildings?

- The pre-defined zoning envelope affected the aesthetics of high-rise building design. By the mid-1920s, a number of architects and critics were writing about a new design approach that some labeled the “setback style.”
- Even when the regulation was no longer in place, some designers still used the zoning setback as an intentional design move to provide some amenity space for commercial usage for the upper levels of the property.

Buildings with unique form due to zoning setback regulations. The zoning regulation required buildings to set back the street-facing façade as the building height increased. As a result, high-rise buildings designed and constructed when the 1916 Zoning Regulation was active all had a terrace-like geometry on the upper portion. Some designers responded to this regulation by putting additional amenities on the terrace rooftop, while some chose to set back the façade more than required distance to create generous terrace space.
Podium allows for larger commercial programs to exist on the bottom floors of the building.

Study feature: 04) Podium
Do commercial buildings with a podium at its base receive a premium bonus during property transaction?

Buildings with a podium that are between one- to ten-stories tall. Podium was a popular design feature of modernist architecture. Many famous buildings constructed after WWII, such as the Lever House and the UN Headquarters, all had a podium. Some recent design, such as the Heart Tower, Beekman Tower, Hampshire’s Dream Hotel (under construction), also included podiums. Podium is useful in that it provides a separated spatial layout that may be home for different commercial real estate programs, turning the building into a mixed-use complex.

A podium is the horizontal base of a tower building, when the difference in orientation and the width between the shaft and the base render the building two separate buildings on top of each other rather than a single integrated building. Due to its form and proportions, podiums conveniently incorporate programs which require horizontal spaces, such as conference halls, or street space such as shops or other public amenities, turning the building into a mixed-use complex.
Identification Strategy

- To assess the external architectural differentiation of the city, we need to examine the geometry of New York City. The NYC DOT has released a 3D model of NYC at the Level of Detail (LOD) 1 to 2 scale, which means that external building features and iconic building features can be identified through each building’s geometry across the entire city.

- For each commercial building in Manhattan, we check to see in the model whether the building contains the four design features, and assign a dummy variable of 1 if yes, and 0 otherwise.
Identification Strategy

- We then classify the geometry of every building in the city, according to our four external architectural features. This map depicts the Manhattan building geometry in 3D and isolates the diagonal intersections, building curvature, zoning setbacks, and podium extrusion buildings across the city.
Using a "pure sample" by eliminating overlapping features in the dataset

- Among 3,141 observations, 161 buildings are located on diagonal roads or intersections, 31 have curvature, 533 have setbacks, and 191 have podium extrusions.
- Some buildings contain more than one design feature: 30 buildings have both setbacks and diagonal intersections; 2 have curvature and diagonal intersection; 1 has setbacks and podium extrusion; 3 are at diagonal intersections and have podium extrusion; 10 buildings have curvature and setbacks.
- Using a pure sample for our study, there are 128 buildings located on diagonal roads and without any other design feature; 19 buildings have curvature exclusively; 492 buildings have setbacks exclusively; 187 buildings have podium extrusions exclusively.

We regrouped our building samples to select the "pure" samples, in order to generate a more accurate statistical result on each of the design features' impact on transaction price.
Descriptive Statistics

A sample of 3,095 transaction records of commercial buildings in New York over the 2001-2018 period.

- Notably, buildings with measured design features yielded higher average transaction prices compared to the control samples.
- Buildings with design features are, on average, taller than the control buildings, except buildings with curvature.
- Most buildings with design features are in Class A or B, while the control buildings are mostly in Class B or C.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Descriptive Statistics</th>
<th>Income</th>
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<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>(Std. Dev.)</td>
</tr>
<tr>
<td>Building Information</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Area</td>
<td>836</td>
<td>(208.0)</td>
</tr>
<tr>
<td>Built Year</td>
<td>2001</td>
<td>(8.0)</td>
</tr>
<tr>
<td>Stories</td>
<td>7.8</td>
<td>(0.6)</td>
</tr>
<tr>
<td>Number Flrs</td>
<td>9.0</td>
<td>(0.9)</td>
</tr>
<tr>
<td>Year Sold</td>
<td>2001</td>
<td>(8.0)</td>
</tr>
<tr>
<td>RCA</td>
<td>761</td>
<td>(462)</td>
</tr>
<tr>
<td>Compstak</td>
<td>761</td>
<td>(462)</td>
</tr>
<tr>
<td>Notable Facts</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Notably, buildings with measured design features yielded higher average transaction prices compared to the control samples.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Buildings with design features are, on average, taller than the control buildings, except buildings with curvature.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Most buildings with design features are in Class A or B, while the control buildings are mostly in Class B or C.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Explaining Transaction Prices

We employ a regression framework to explain transaction price with a series of design treatment variables.

We estimated a semi-log linear regression model where we explain the transaction price per square meter for a given building (i) as a cross-section, where \((X_i)\), building features, time and location fixed effects (sub-market), buyer, seller and lender types and \((G_i)\) is the vector of design feature dummy variables, where the value is 1 if the building design feature is present was for a building (i).

\[
\log P_i = \alpha + \beta X_i + \delta G_i + \epsilon
\]

The explanatory variable is the transaction price per square meter for a given building. We observe individual lease contracts over the 2011 to 2018 period across Manhattan, New York.
**Results (1): Diagonality**

We explain the log transaction price per square meters by location and time, building features and transaction features fixed effects.

Table 3: Architectural Design Features - Diagonal Intersection  
(Dependent Variable: Logarithm of transaction price per square meter)

<table>
<thead>
<tr>
<th></th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diagonal</td>
<td>-0.044</td>
<td>0.060</td>
<td>0.069</td>
</tr>
<tr>
<td></td>
<td>[0.055]</td>
<td>[0.054]</td>
<td>[0.048]</td>
</tr>
<tr>
<td>Location and Transaction Time FE</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td>Building Features FE</td>
<td>NO</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td>Transaction Features FE</td>
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<td>NO</td>
<td>YES</td>
</tr>
<tr>
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<td>7.108***</td>
<td>7.191***</td>
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<tr>
<td></td>
<td>[0.044]</td>
<td>[0.833]</td>
<td>[0.858]</td>
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<tr>
<td>Observations</td>
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<td>2.397</td>
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<tr>
<td>R-squared</td>
<td>0.344</td>
<td>0.447</td>
<td>0.496</td>
</tr>
<tr>
<td>F Adj R-Squared</td>
<td>0.34</td>
<td>0.44</td>
<td>0.48</td>
</tr>
</tbody>
</table>

Notes: Robust standard errors in brackets, *** p<0.01, ** p<0.05, * p<0.1. For the sake of purity, we ran the regression for the dataset without any overlapping features. However, if we run the regression for the dataset including the overlapping features, column (3) would yield a positively significant coefficient of 10.8 percent for the diagonal design feature.

Notes:
- For the sake of purity, we ran the regression for the dataset without any overlapping features. However, if we run the regression for the dataset including the overlapping features, column (3) would yield a positively significant coefficient of 10.8 percent for the diagonal design feature.
- The results of the models explain between 34 and 48 percent of the transacted price of a building.
**Results (2): Curvature**

We explain the log transaction price per square meters by location and time, building features and transaction features fixed effects.

Notes:

- For the sake of purity, we ran the regression for the dataset without any overlapping features. However, if we run the regression for the dataset including the overlapping features, column (3) would yield a positively significant coefficient of 16.8 percent for the curvature design feature.
- The results of the models explain between 34 and 48 percent of the transacted price of a building.

<table>
<thead>
<tr>
<th></th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Curvy</strong></td>
<td>0.274***</td>
<td>0.115</td>
<td>0.137*</td>
</tr>
<tr>
<td></td>
<td>[0.094]</td>
<td>[0.073]</td>
<td>[0.082]</td>
</tr>
<tr>
<td>Location and Transaction Time FE</td>
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<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td>Building Features FE</td>
<td>NO</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td>Transaction Features FE</td>
<td>NO</td>
<td>NO</td>
<td>YES</td>
</tr>
<tr>
<td><strong>Constant</strong></td>
<td>7.773***</td>
<td>6.959***</td>
<td>7.090***</td>
</tr>
<tr>
<td></td>
<td>[0.045]</td>
<td>[0.832]</td>
<td>[0.855]</td>
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<tr>
<td><strong>Observations</strong></td>
<td>2,371</td>
<td>2,288</td>
<td>2,288</td>
</tr>
<tr>
<td><strong>R-squared</strong></td>
<td>0.347</td>
<td>0.454</td>
<td>0.496</td>
</tr>
<tr>
<td><strong>F Adj R-Squared</strong></td>
<td>0.34</td>
<td>0.45</td>
<td>0.48</td>
</tr>
</tbody>
</table>

Notes: Robust standard errors in brackets, *** p<0.01, ** p<0.05, * p<0.1. For the sake of purity, we ran the regression for the dataset without any overlapping features. However, if we run the regression for the dataset including the overlapping features, column (3) would yield a positively significant coefficient of 16.8 percent for the curvature design feature.
Results (3): Setbacks

We explain the log transaction price per square meters by location and time, building features and transaction features fixed effects.

Notes:

- For the sake of purity, we ran the regression for the dataset without any overlapping features. However, if we run the regression for the dataset including the overlapping features, column (3) would yield a negatively significant coefficient of 11.8 percent for the setbacks design feature.
- The results of the models explain between 34 and 48 percent of the transacted price of a building.

<table>
<thead>
<tr>
<th></th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Setbacks</strong></td>
<td>-0.172***</td>
<td>-0.141***</td>
<td>-0.129***</td>
</tr>
<tr>
<td></td>
<td>[0.026]</td>
<td>[0.027]</td>
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<tr>
<td><strong>Location and Transaction Time FE</strong></td>
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<tr>
<td><strong>Building Features FE</strong></td>
<td>NO</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td><strong>Transaction Features FE</strong></td>
<td>NO</td>
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<td>YES</td>
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<td><strong>Constant</strong></td>
<td>7.795***</td>
<td>6.832***</td>
<td>6.967***</td>
</tr>
<tr>
<td></td>
<td>[0.042]</td>
<td>[0.086]</td>
<td>[0.824]</td>
</tr>
<tr>
<td><strong>Observations</strong></td>
<td>2,862</td>
<td>2,761</td>
<td>2,761</td>
</tr>
<tr>
<td><strong>R-squared</strong></td>
<td>0.350</td>
<td>0.450</td>
<td>0.488</td>
</tr>
<tr>
<td><strong>F Adj R-Squared</strong></td>
<td>0.34</td>
<td>0.44</td>
<td>0.48</td>
</tr>
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Notes: Robust standard errors in brackets, *** p<0.01, ** p<0.05, * p<0.1. For the sake of purity, we ran the regression for the dataset without any overlapping features. However, if we run the regression for the dataset including the overlapping features, column (3) would yield a negatively significant coefficient of 11.8 percent for the setbacks design feature.
Results (4): Podium

We explain the log transaction price per square meters by location and time, building features and transaction features fixed effects.

Notes:

- For the sake of purity, we ran the regression for the dataset without any overlapping features. However, if we run the regression for the dataset including the overlapping features, column (3) would yield a positively significant coefficient of 14.5 percent for the podium extrusion design feature.
- The results of the models explain between 34 and 48 percent of the transacted price of a building.

<table>
<thead>
<tr>
<th>Table 6: Architectural Design Features - Podium</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Dependent Variable: Logarithm of transaction price per square meter)</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Podium</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Location and Transaction Time FE</td>
</tr>
<tr>
<td>Building Features FE</td>
</tr>
<tr>
<td>Transaction Features FE</td>
</tr>
<tr>
<td>Constant</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Observations</td>
</tr>
<tr>
<td>R-squared</td>
</tr>
<tr>
<td>F Adj R-Squared</td>
</tr>
</tbody>
</table>

Notes: Robust standard errors in brackets, *** p<0.01, ** p<0.05, * p<0.1. For the sake of purity, we ran the regression for the dataset without any overlapping features. However, if we run the regression for the dataset including the overlapping features, column (3) would yield a positively significant coefficient of 14.5 percent for the podium extrusion design feature.
Results (5): All features

We explain the log transaction price per square meters by location and time, building features and transaction features’ fixed effects.

Notes:

• For the sake of purity, we ran the regression for the dataset without any overlapping features. However, if we include the overlapping features, column (3) would yield a positively significant coefficient of 10.5 percent for diagonal intersection, a positively significant coefficient of 20.9 percent for curvature, a negatively significant coefficient of 12.9 percent for setbacks, and a positively significant coefficient of 16.5 percent for podium extrusion.

• The results of the models explain between 34 and 48 percent of the transacted price of a building.

Table 7: Architectural Design Features - Diagonal Intersection, Curvature, Setbacks, and Podium
(Independent Variable: Logarithm of transaction price per square meter)

<table>
<thead>
<tr>
<th></th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
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</thead>
<tbody>
<tr>
<td>Diagonal</td>
<td>-0.049</td>
<td>0.049</td>
<td>0.049</td>
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<tr>
<td></td>
<td>[0.055]</td>
<td>[0.053]</td>
<td>[0.048]</td>
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<tr>
<td>Curvy</td>
<td>0.279***</td>
<td>0.141**</td>
<td>0.159**</td>
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<tr>
<td></td>
<td>[0.093]</td>
<td>[0.072]</td>
<td>[0.080]</td>
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<tr>
<td>Setbacks</td>
<td>-0.174***</td>
<td>-0.150***</td>
<td>-0.136***</td>
</tr>
<tr>
<td></td>
<td>[0.026]</td>
<td>[0.026]</td>
<td>[0.026]</td>
</tr>
<tr>
<td>Podium</td>
<td>0.117***</td>
<td>0.150***</td>
<td>0.146***</td>
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<tr>
<td></td>
<td>[0.041]</td>
<td>[0.045]</td>
<td>[0.044]</td>
</tr>
<tr>
<td>Location and Transaction Time FE</td>
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</tr>
<tr>
<td>Building Features FE</td>
<td>NO</td>
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<td>YES</td>
</tr>
<tr>
<td>Transaction Features FE</td>
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<td>NO</td>
<td>YES</td>
</tr>
<tr>
<td>Constant</td>
<td>7.808***</td>
<td>6.834***</td>
<td>7.017***</td>
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<td></td>
<td>[0.040]</td>
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<tr>
<td>Observations</td>
<td>3.203</td>
<td>3.095</td>
<td>3.095</td>
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<td>R-squared</td>
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<td>0.441</td>
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<td>F Adj R-Squared</td>
<td>0.34</td>
<td>0.43</td>
<td>0.47</td>
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</tbody>
</table>

Notes: Robust standard errors in brackets. *** p<0.01, ** p<0.05, * p<0.1. For the sake of purity, we ran the regression for the dataset without any overlapping features. However, if we run the regression for the dataset including the overlapping features, column (3) would yield a positively significant coefficient of 10.5 percent for the diagonal intersection, a positively significant coefficient of 20.9 percent for the curvature, a negatively significant coefficient of 12.9 percent for the setbacks, and a positively significant coefficient of 16.5 percent for the podium extrusion.
When controlling for location and transaction time, building features and transaction features, the result of the hedonic analysis suggests that buildings with unique design elements have a premium compared to those without. We show our initial findings in the following graph.

Notable findings:
- Curvature, setbacks and podium extrusions differentiate a commercial building's financial value by 15.9 percent, -13.6 percent and 14.6 percent respectively.
- Diagonality does not have a significant financial impact on transaction price for commercial properties in New York City.

DATA SOURCES:
- Real Capital Analytics
- Compstak
- NYC DoITT
- NYC Planning

SIGNIFICANCE***
Asterisks in a regression table indicate the level of the statistical significance of a regression coefficient.
*** p<0.01, ** p<0.05, * p<0.1

COEFFICIENT %
The standard error is our estimate of the standard deviation of the coefficient.

NOTE:
The regression model controls for location and transaction time, building features (age, number of floors, building area, land parcel area, building class, renovation, and walk score), and transaction features (buyer type, seller type, and lender type)
What surprised us?

Some features had no impact on price while others produced positively or negatively significant results.

Notable findings:

- Curvature, setbacks and podium extrusions differentiate a commercial building's financial value by 15.9 percent, -13.6 percent and 14.6 percent respectively.
- Diagonality does not have a significant financial impact on transaction price for commercial properties in New York City.

"Although building setbacks are formally similar to podium extrusions, the former has a negative value impact on transaction price for commercial properties while the latter creates a value premium. We speculate this is because the terrace-like form for the upper portion of tall buildings reduces rentable building footprint significantly and adds difficulty in floor plan layouts. Unlike buildings with podiums, buildings with setbacks lose square footage without providing enough mixed-use commercial amenities to balance the loss."
- Helena H Rong

"Even diagonality does not have a significant impact on transaction price, at the beginning, we hypothesized that buildings sitting on diagonal intersections would yield a positive significant coefficient from the regression model mainly for two reasons. First, a diagonal intersection is likely to create additional open space compared to other typical perpendicular intersections. There are several parks at diagonal intersections in Manhattan, such as the Greeley Square Park, Madison Square Park, Dante Park, and so forth. Second, we considered sites on a diagonal intersection as eye-catching locations in Manhattan, hence attracting some high-profile building projects. However, it is important to realize that these sites might impose unexpected limitations on building design and construction, especially constraining the footprint size."
- Juncheng Yang
Conclusions

Our results suggest that there is a significant economic impact of certain architectural design interventions that aesthetically and functionally differentiate the building and that this topic requires further research.

- **CONTRIBUTION:** Our contribution is to create a relational understanding between building geometry, geography and real estate valuation techniques.
- **AGENCY:** Expanding the knowledge base of design and its impact on finance and economics will enable designers and real estate economists to engage in interdisciplinary exchange. Further, it may also magnify the agency of design in fields that emphasize quantitative analysis.
- **NEW DATASET:** With increasing computational power to measure and assess different parts of the built environment, we can create new data to include in our pricing model.