
ICONICITY
CONSISTENCY
LITERAL GREENS
NON-90 DEGREE
SOLID VS. VOID
DOUBLE HEIGHT
INTERIOR WALLS
ADAPTIVE REUSE
BALCONIES
DAYLIGHT
VIEWS

MIT SA+P MIT SCHOOL OF ARCHITECTURE AND PLANNING

CENTER FOR REAL ESTATE

MIT Real Estate Innovation Lab

The Value of Design in Asset Pricing

Measuring the Financial Impact of Architectural Design Features

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

Helena H Rong is a Research Associate at the MIT REI Lab and studies the intersection of design, technology and finance.

Juncheng Yang is a Research Associate at the MIT REI Lab with training in architecture, urban design and economics.

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.

There is a gap in communication between two worlds: design and finance

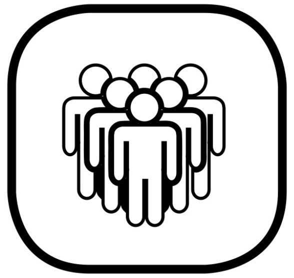
Disciplinary Challenge

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

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.

Challenge



- 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.

Designers lack agency in the valuation of the works they produce

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.

Building Features - Mean (Std. Dev.)
Age of building (years)
Size of building (sq. ft. thousands)
Stories of building
Renovated status
Time since renovation (years)

Table 1: Global Office Market Transaction and Building Statistics
(Complete Transactions Greater than US $ 10 Million - 2007 to 2013)

	London	Paris	Tokyo	Hong Kong	New York	Los Angeles
Transaction Price - Mean (Std. Dev.)						
Transaction price ($ mln)	138.40	108.70	74.20	45.20	125.20	52.47
	(201.40)	(161.90)	(144.10)	(87.80)	(234.20)	(72.40)
Log transaction price	18.16	18.01	17.45	17.08	17.78	17.28
	(1.06)	(0.97)	(1.01)	(0.85)	(1.23)	(0.90)
Price per square foot	1,119.45	842.06	958.64	1,464.67	537.99	299.43
	(761.60)	(496.56)	(682.93)	(779.97)	(500.87)	(187.38)
Log price per square foot	6.82	6.58	6.67	7.16	5.95	5.55
	(0.66)	(0.58)	(0.67)	(0.54)	(0.84)	(0.56)
Building Features - Mean (Std. Dev.)						
Age of building (years)	50.41	51.87	20.74	18.89	62.45	28.66
	(64.17)	(64.75)	(13.03)	(12.48)	(34.98)	(19.08)
Size of building (sq. ft. thousands)	139.90	147.44	96.19	40.92	285.26	186.36
	(178.20)	(176.65)	(220.18)	(84.08)	(387.79)	(217.46)
Stories of building	8.23	7.83	10.19	30.97	13.45	7.23
	(5.54)	(6.11)	(6.28)	(12.47)	(12.69)	(8.50)
Renovated status	0.27	0.22	0.05	0.03	0.45	0.29
	(0.44)	(0.42)	(0.21)	(0.16)	(0.50)	(0.45)
Time since renovation (years)	2.68	1.42	0.34	0.10	6.28	3.74
	(7.07)	(4.01)	(2.47)	(0.70)	(10.06)	(9.98)
Investor Type - Percentage						
Equity Fund	0.13	0.08	0.03	0.02	0.14	0.22
Institutional	0.41	0.49	0.15	0.04	0.12	0.13
Private	0.24	0.17	0.33	0.66	0.56	0.47
Public	0.12	0.18	0.40	0.05	0.08	0.11
Owner occupied	0.04	0.04	0.09	0.09	0.09	0.07
Unknown	0.06	0.04	0.01	0.14	0.01	-
Seller Type - Percentage						
Equity Fund	0.11	0.09	0.04	0.03	0.10	-
Institutional	0.43	0.50	0.20	0.11	0.14	0.12
Private	0.19	0.09	0.36	0.54	0.54	0.21
Public	0.19	0.23	0.24	0.12	0.10	0.45
Owner occupied	0.04	0.07	0.14	0.05	0.11	0.13
Unknown	0.04	0.02	0.03	0.13	0.02	0.02
Year of Transaction - Percentage						
2007	0.15	0.11	0.14	0.20	0.26	0.27
2008	0.10	0.09	0.16	0.09	0.12	0.12
2009	0.12	0.11	0.10	0.14	0.03	0.04
2010	0.13	0.16	0.14	0.18	0.10	0.08
2011	0.13	0.18	0.13	0.11	0.13	0.11
2012	0.17	0.18	0.14	0.14	0.18	0.17
2013	0.21	0.17	0.19	0.15	0.18	0.21
Number of Transactions	784	492	1,316	516	978	656

Notes: Table 1 gives the descriptive statistics for the six global property markets in Europe, Asia and North America for transactions greater than US $ 10 million for 2007 to 2013. The table documents the mean and standard deviation of transaction prices, building features, investor and seller types and year of transaction.

Source: Chegut, Andrea M., Piet M. A. Eichholtz, and Paulo J. M. Rodrigues. "Spatial Dependence in International Office Markets." J Real Estate Finan Econ 51, no. 2 (November 9, 2014): 317–350.

Financial valuation considers involvement of awarded architects as measure of design

How Finance Sees 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 of what architects do - the physical forms they bring to their designs

MIT Real Estate Innovation Lab

The Value of Awarded Design in Real Estate Asset Pricing

About the Project

Awarded design is based on the achievement of the architect and/or the architecture firm receiving prestigious awards from the industry such as the Pritzker prize, AIA Architecture Firm Award, the Architectural Innovation Award of the Wall Street Journal to name just a few.

To measure financial performance, I use several datasets, Real Capital Analytics, Compstak, Walkscore and NYC public data for New York City. To identify awarded design and compare it to non-awarded design, I employ a matched-pair analysis.

I find 846 building transactions with 89 awarded design transactions that are matched geographically to 757 nonawarded design transactions within a quarter mile radius over the 2000 to 2017 period.

About the Researchers

Minkoo Kang (MSRED 19') is an architect and urban researcher at the MIT REI Lab.

Dr. Andrea Chegut is a research scientist at MIT that uncovers innovation in the built environment.

About the Lab

The MIT Real Estate Innovation Lab is an R&D lab at the MIT's SA+P, Center for Real Estate that works with public and private data providers to link design and innovation to financial performance in the built environment.

Support

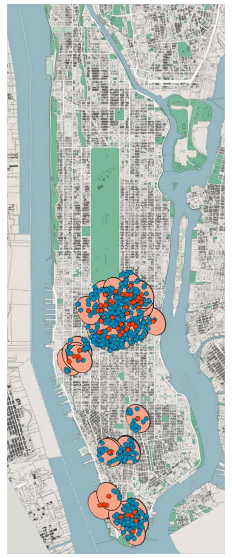
We are grateful for the support of our data providers, and in particular, the founding lab partners:

→ Award Criteria

A total of 18 awarded architects/firms have designed 56 buildings in Manhatta, and 89 transactions were observed. Within the 18 firms, 4 firms have received more than 2 awards from 3 award categories

↓ 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).



Royal Gold Medal
Organization RIBA
How often Annual
First awarded 1848
From 1950 69 awarded

Gold Medal
Organization AIA
How often Annual
First awarded 1907
From 1950 59 awarded

Gold Medal
Organization UIA
How often Triennial
First awarded 1984
From 1950 26 awarded

Golden Lion
Organization Venice Biennale
How often Biennial
First awarded 2000
From 1950 12 awarded

Innovator Awards
Organization WSJ
How often Annual
First awarded 2010
From 1950 7 awarded

National Desgin Award
Organization Cooper Hewitt
How often Annual
First awarded 2000
From 1950 26 awarded

Architecture Firm Award
Organization AIA
How often Annual
First awarded 1962
From 1950 55 awarded

Pritzker Prize
Organization Pritzker Foundation
How often Annual
First awarded 1978
From 1950 41 awarded

AWARDED FIRMS
Architecture firms who won the AIA Architecture Firm Award

Davis Brody Bond	'75	100 William Five Manhattan West
Gensler	'00	233 Spring Street 161 6th Avenue
KPF	'90	745 7th Avenue Five TIme Square One Vanderbilt 111 Murray Street 1100 6th Avenue 441 8th Avenue 10 Hudson Yards
Murphy / Jahn	'05	425 Lexington Avenue 65 East 55th Street
Hugh Stubbins	'67	Citi Group Center

AWARDED ARCHITECTS
Architects who won the lifetime achievement awards and/or innovation awards

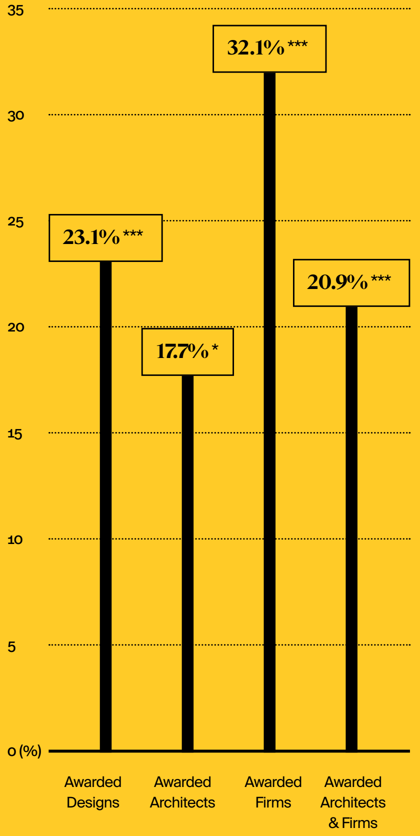
Aldo Rossi	'90	557 Broadway 555 Broadway
Alvar Alto	'63	809 UN Plaza
Jean Nouvel	'01 '08	45-47 W 53rd St
César Pelli	'95	3 World Financial Center 4 World Financial Center 900 3rd Avenue NY Mercantile Exchange
Norman Foster	'83 '94 '99	610 Lexington Avenue 425 Park Avenue
Fumihiko Maki	'11 '93 '93	51 Astor Place
Mies van der Rohe	'59 '60	Seagram Building
Philip Johnson	'78 '79	5 East 44th Street Sony Plaza Lipstick Building
Walter Gropius	'56 '59	200 Park Avenue

AWARDED ARCHITECTS & FIRMS
Architects/firms who won both award groups

Edward L. Barnes	'07 '80	499 Park Avenue 7 Byant Park
I.M.Pei	'10 '14 '68 '79 '83 '03	JP Morgan Chase HQ Deutsche Bank HQ 31 West 52nd Street
Kevin Roche	'93 '82 '74	125 West 55th Street Ave of Americas Plaza 787 Seventh Avenue
Skidmore Orell & Merril (SOM)	'57 '83 '88 '96	12 West 57th Street Paine Webber Building Marine Midland Bank Bertelsmann Building 300 Madison Avenue 34-36 East 51st Street One Manhattan West Two Manhattan West 450 Lexington Avenue 461 5th Avenue 510 5th Avenue Worldwide Plaza 830 3rd Avenue

↓ Study Results

When controlling for location and transaction time, building features and transaction features, the result of the hedonic analysis suggests that buildings designed by awarded architects/firms are transacted with a **23.1% premium** than buildings that are designed by non-awarded architects.



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.

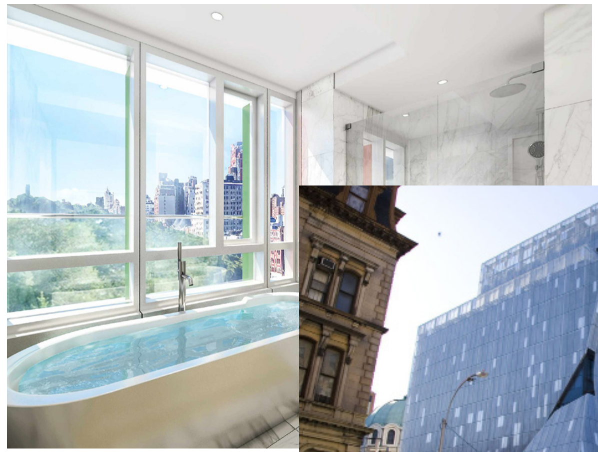
NOTE:
The regression model controls for location and transaction time, building features (age, number of floors, building area, land parcel area, building class, renovation, and walk score), and transaction features (buyer type, seller type, and lender type)

Design is currently left out of the equation of financial valuation

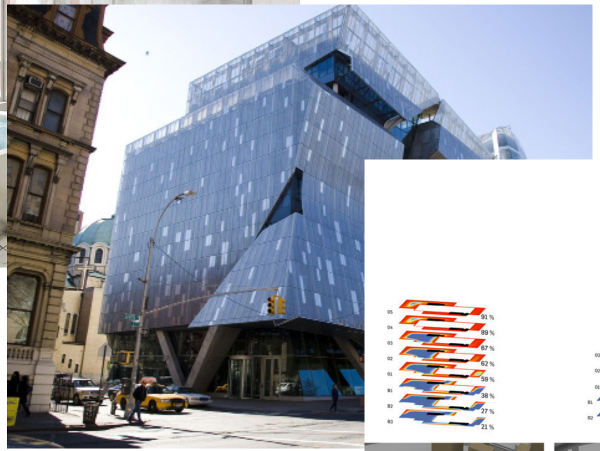
- Design and sustainability should have a bearing in every building's outcomes due to the high value proposition that it brings.

What Designers Consider

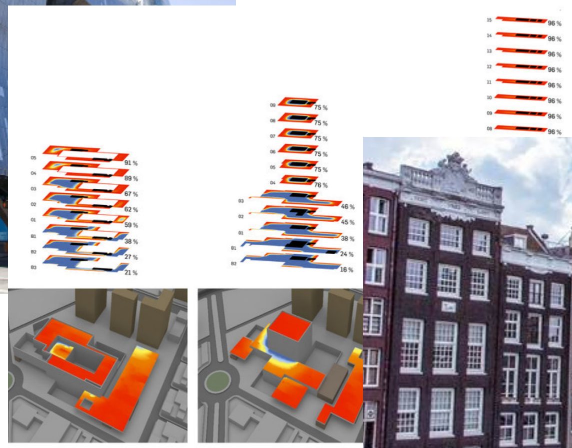
Practicing architects are confronted with defending the value of both functional and aesthetic building needs, such as daylight, views, materiality and spatial contextuality.



Views



Materiality



Daylight

Spatial contextuality

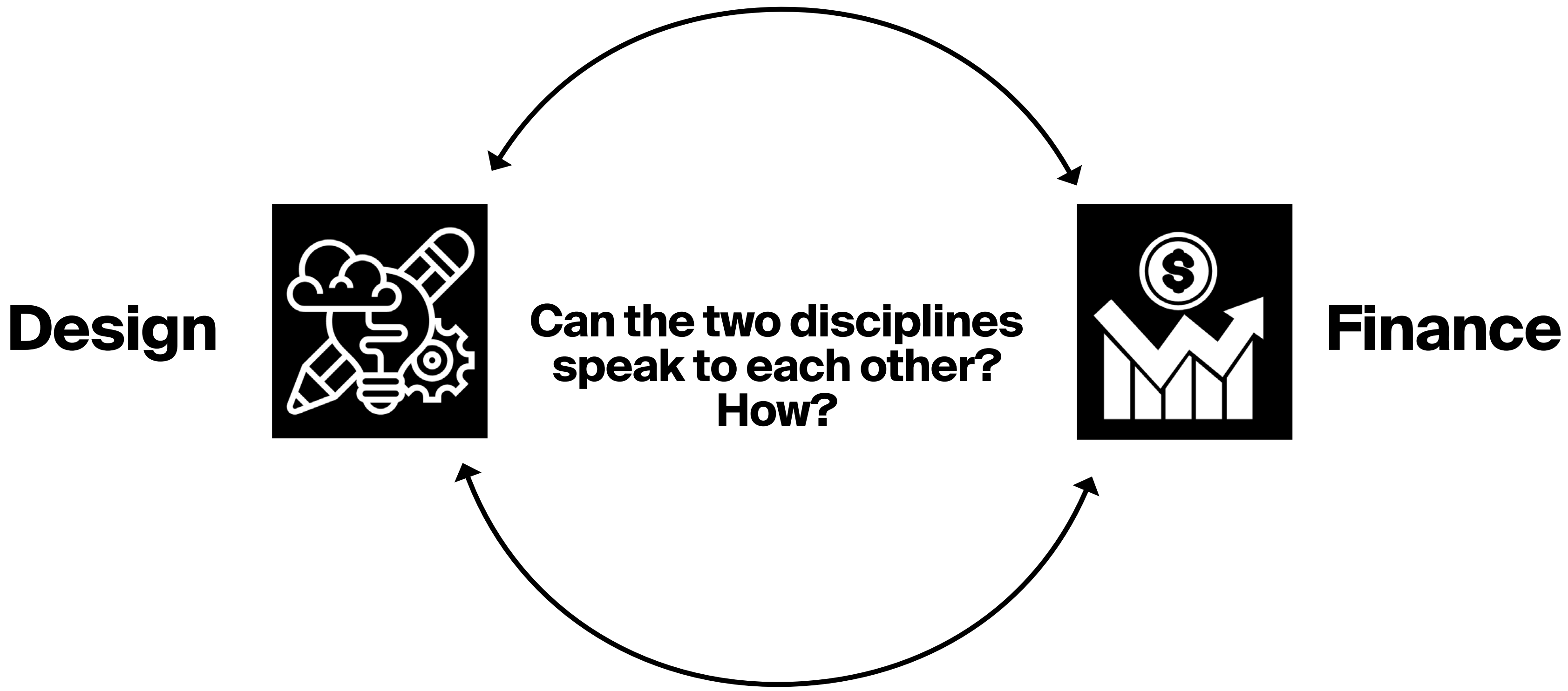
How can we begin to collect and measure these qualitative attributes design brings?

Can we break down the disciplinary barrier between design and finance?

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 diculty of interpreting the current research results by isolating individual design attributes or removing confounding factors.



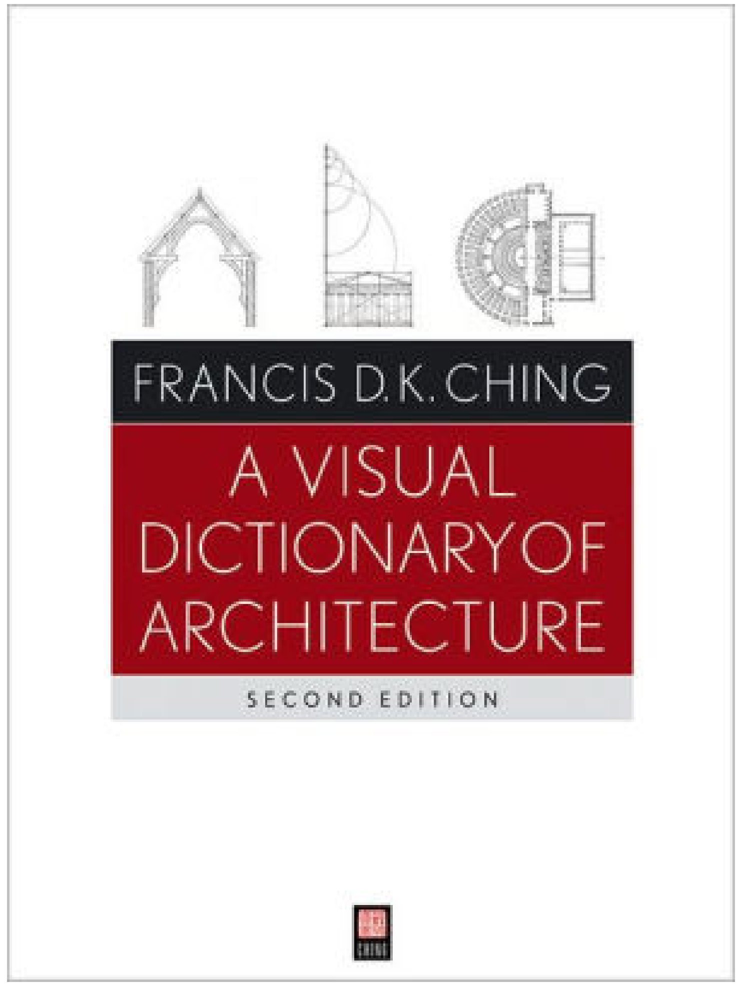
Existing Literature

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

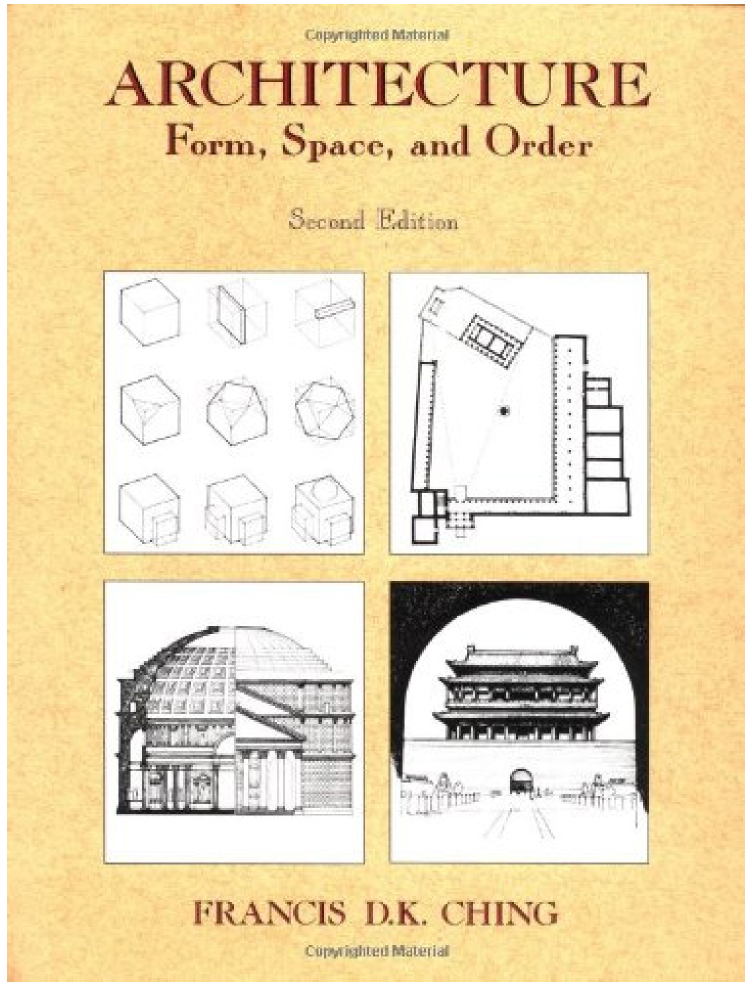
DESIGN LITERATURE

- 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 of 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?

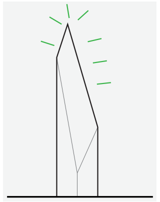
- **Iconicity**: measures the recognizability of a built structure and its cultural impacts
- **Consistency and variations**: measures how different a building is from its surroundings
- **Literal greens**: quantifies the percentage of vegetation and green surfaces
- **Non-90 degree angles**: quantifies 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

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.

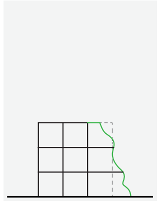
1. ICONICITY

520 W28 St, New York by Zaha Hadid Architects



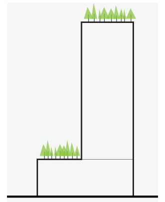
2. CONSISTENCY AND VARIATION

Streets of Amsterdam



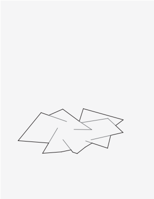
3. LITERAL GREENS

1000 Trees by Sou Fujimoto, Paris



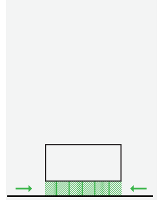
4. NON-90 DEGREE ANGLES

Jewish Museum by Daniel Libeskind, Berlin



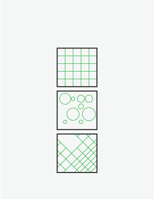
5. PUBLIC-TO-PRIVATE RATIO

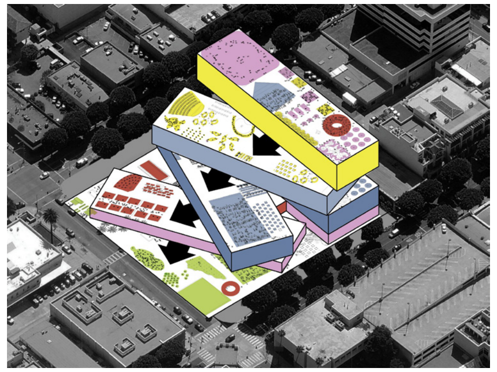
Timmerhuis by OMA, Rotterdam



6. SPATIAL FLEXIBILITY

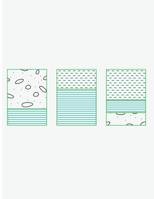
The Plaza at Santa Monica by OMA





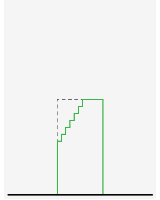
7. MATERIALITY

Cooper Union by Morphosis, New York City



8. SETBACKS

500 Fifth Avenue, New York City



Design Features Inventory

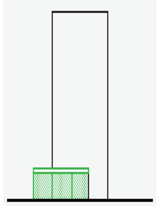
We brainstormed and identified 22 design features as quantifiable features which we can collect and evaluate to construct correlations between design and real estate market value.

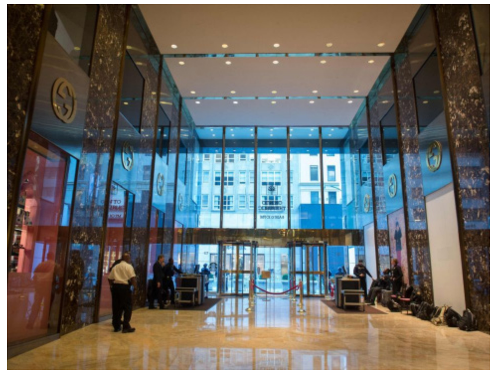
Can we quantify design features? If so, with what metrics?

- 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

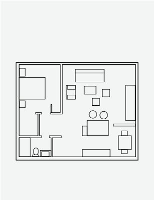
Trump Tower, New York City

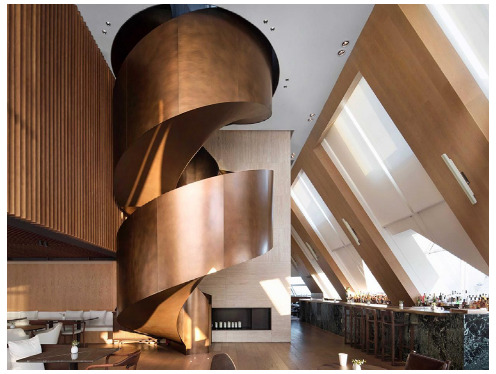




10. INTERIOR DESIGN

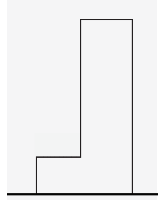
EDITION hotel by Neri+Hu, Shanghai





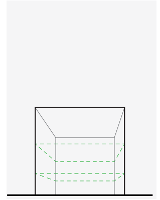
11. PODIUM EXTRUSION

1000 Trees by Sou Fujimoto, Paris



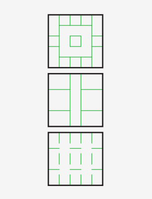
12. DOUBLE/TRIPLE HEIGHT SPACES

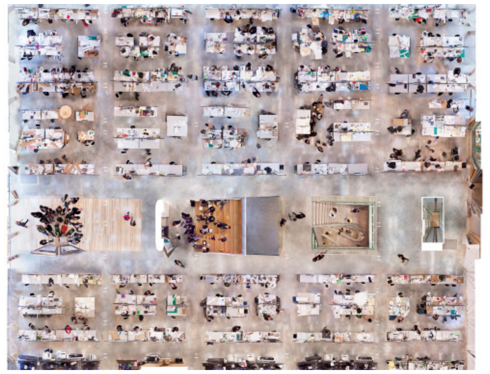
520 W28 St, New York by Zaha Hadid Architects



13. NUMBER OF INTERIOR WALLS

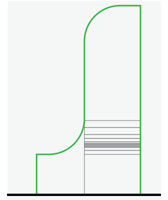
Milstein Hall by OMA, Ithaca, NY





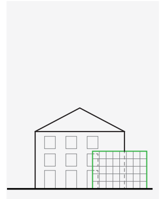
14. CURVATURE

La Folie Divine by Farshid Moussavi



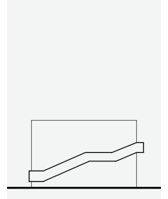
15. ADAPTIVE RE-USE BUILDINGS

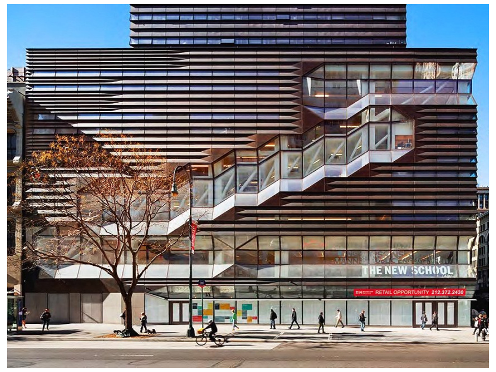
Waterhouse by Neri+Hu, Shanghai



16. NUMBER OF STAIRCASES

New School by SOM, New York City





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

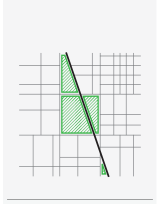
- Diagonal vs. grid: measures whether urban form impacts the market value
- Daylight: quantifies the amount of daylight each space receives
- Views: quantifies the contents of a view
- Levels of customization: assess how similar a building is to itself (the degree to which customized parts are used)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

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.

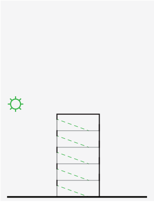
17. DIAGONAL VS. GRID

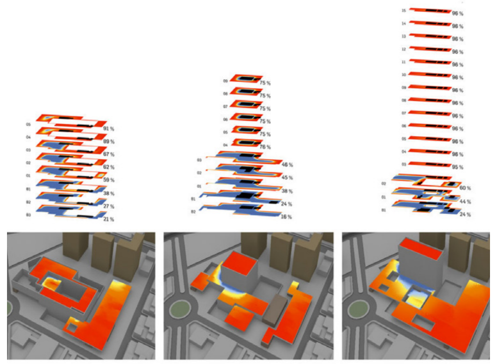
Flat Iron Building, New York City



18. DAYLIGHT

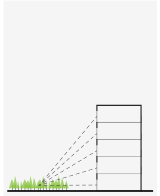
WSP Building Ecology





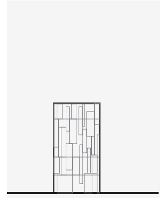
19. VIEWS

Harlem Condos, New York City



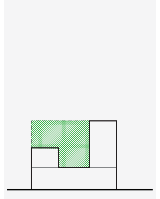
20. LEVEL OF CUSTOMIZATION

8 Spruce St by Frank Ghery, New York City



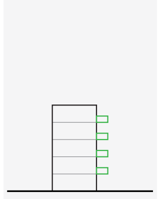
21. SOLID/VOID RATIO

Axel Springer Campus by OMA, Berlin



22. BALCONIES

Plaza 400, New York City

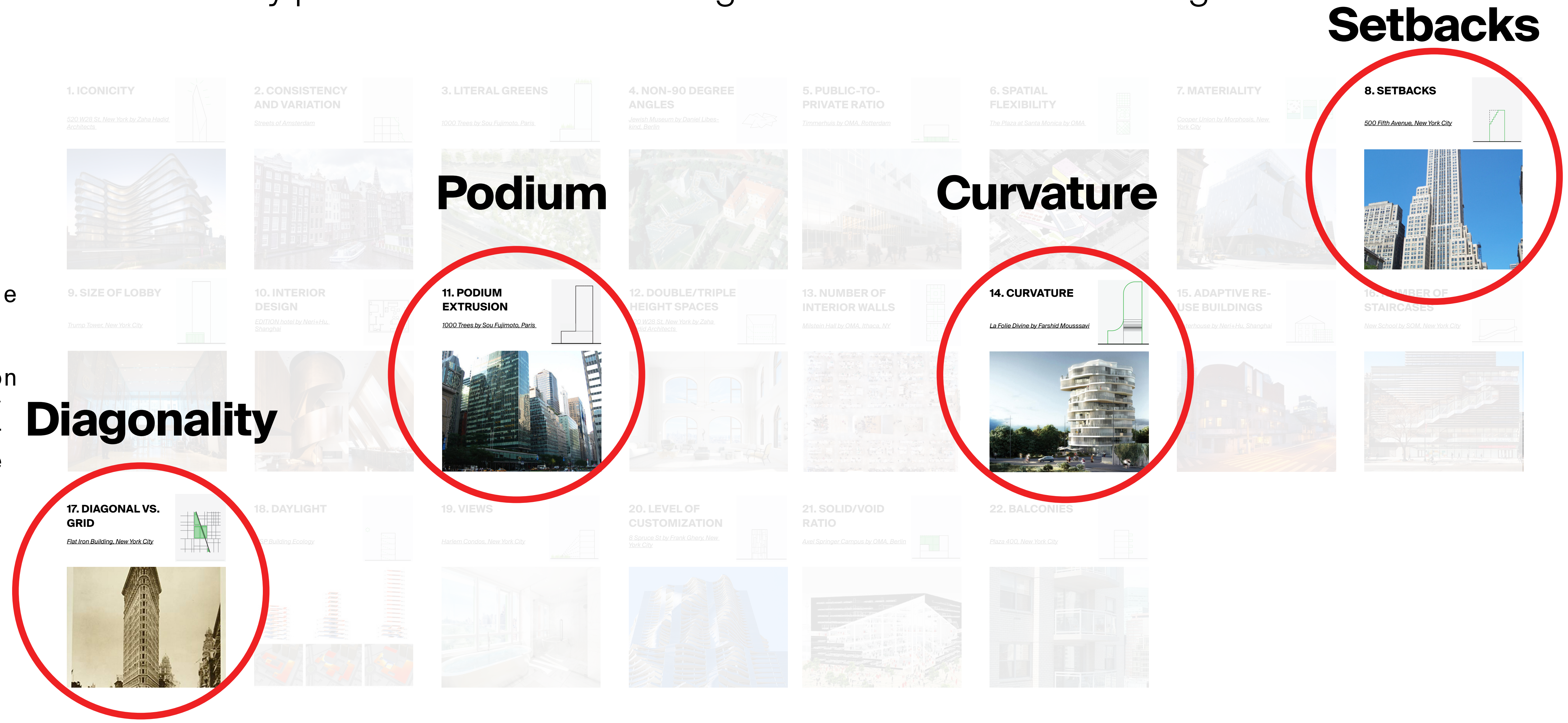


We pick four architectural formal features to conduct further studies with actual transaction data

Four External Architectural Formal Features as Case Study

We selected and focused on four independent features of external building form to see whether they produce noticeable changes on the exterior of buildings.

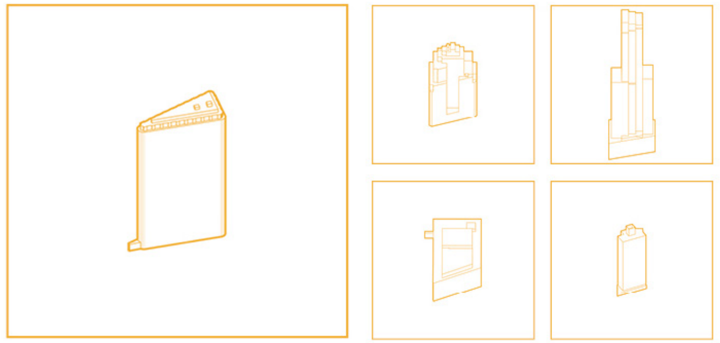
```
Selected Features:

•   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
```



Buildings located on diagonal intersections have a unique geometry due to the irregular shape of the site

Study feature: 01) Diagonality

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



- 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.

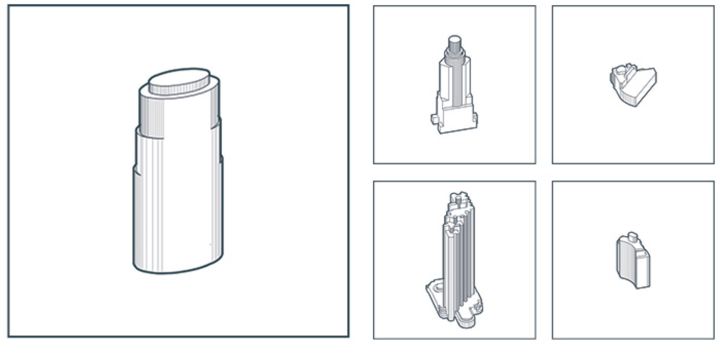
Buildings located on diagonal roads and intersections. Given that Manhattan uses an extensive urban grid to organize its urban space, most building sites are contained within rectangular blocks. Hence, building sites along diagonal roads are usually non-rectangular. Since land value is so high in Manhattan 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.

Buildings with curvature are generally more iconic, but require higher construction costs

- 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: 02) Curvature

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



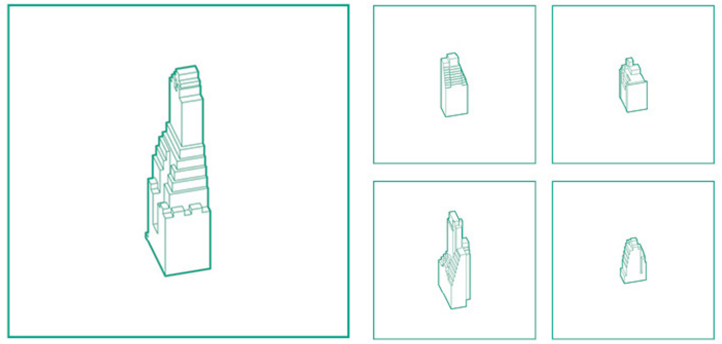
Buildings with a curved feature in either plan or elevation. Curved features, especially large-scale features, might require special design of structural system and increase the budget. However, curved features "... can be more vigorous and expressive in nature. Their shapes change dramatically as we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

Setbacks is a result of zoning regulation in 1916, but remained as a style even when the regulation was no longer in place

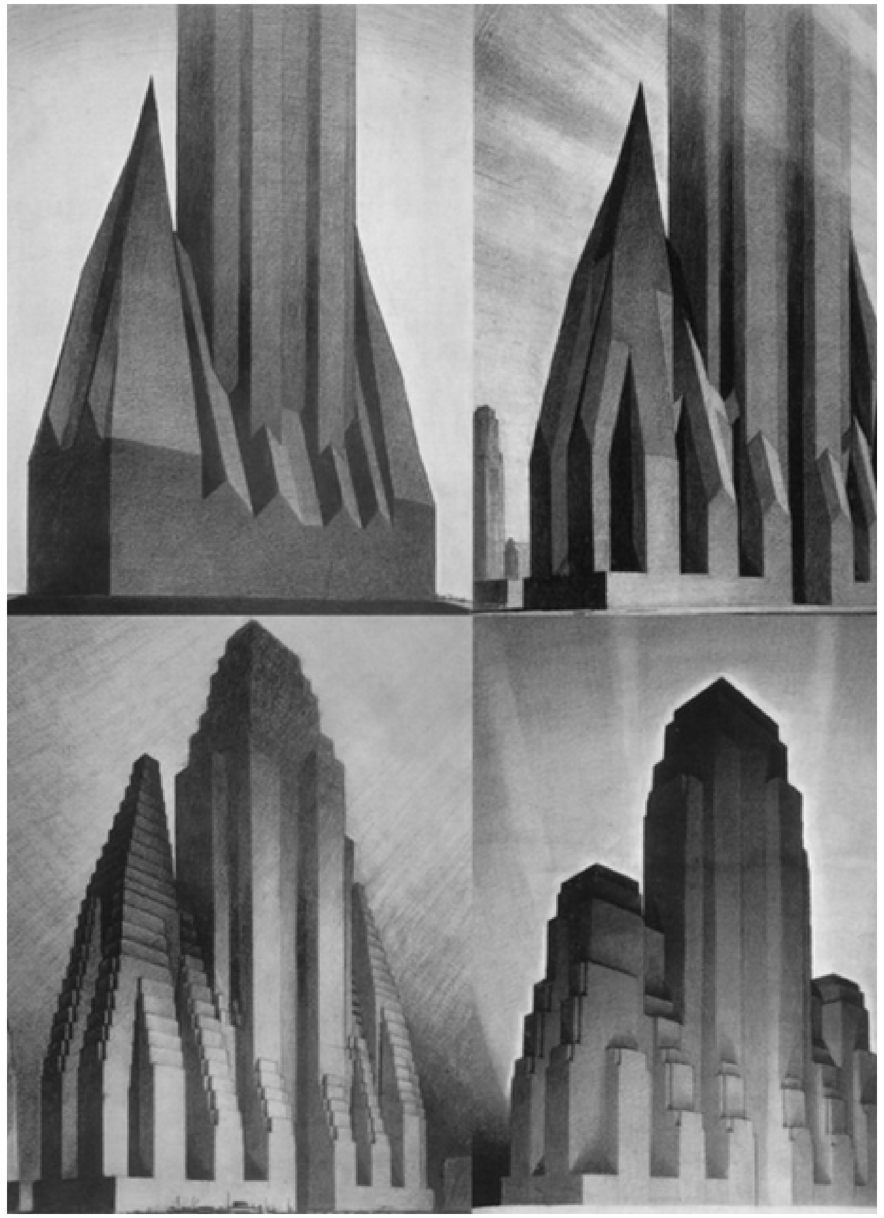
Study feature: 03) Setbacks

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.

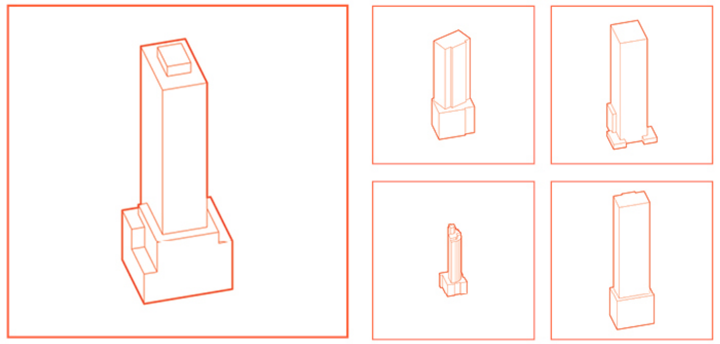


Study feature: 04) Podium

Do commercial buildings with a podium at its base receive a premium bonus during property transaction?

Podium allows for larger commercial programs to exist on the bottom floors of the building

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.

Using RCA and Compstak data we examine the transaction characteristics of commercial buildings in New York

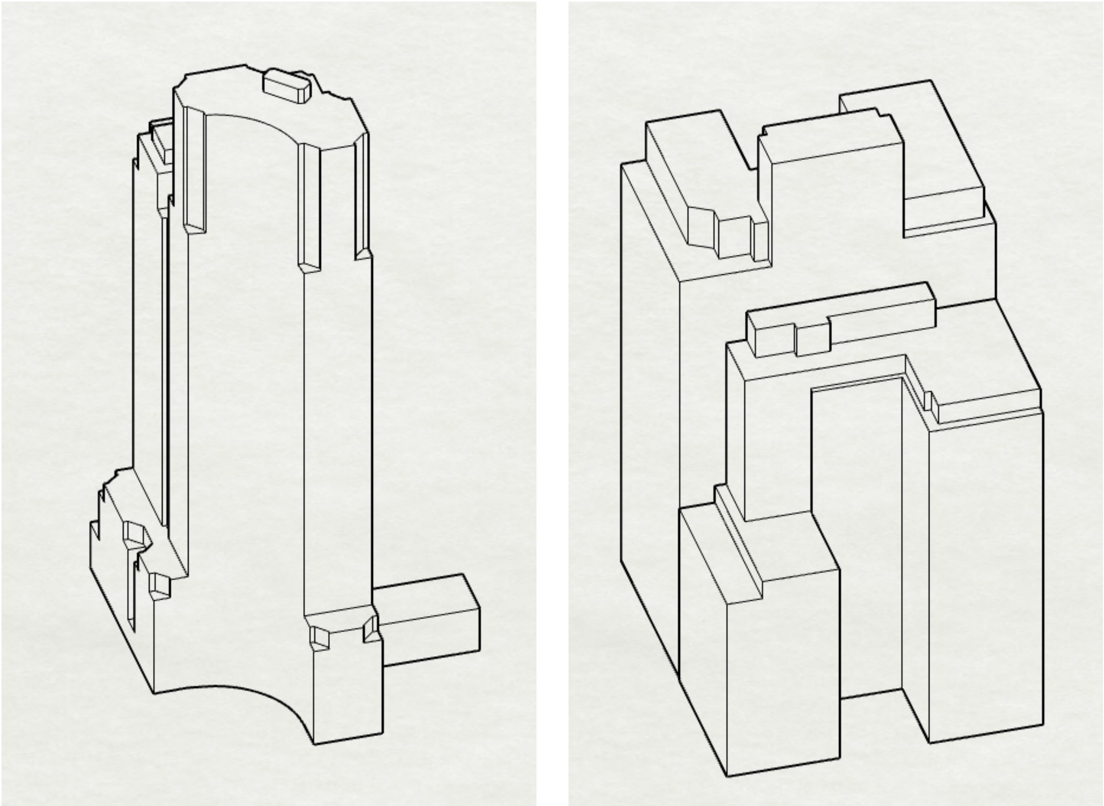
Identification Strategy

Using LOD2 3D model of New York to label new features

Identification Strategy

- To assess the external architectural differentiation of the city, we need to examine the geometry of New York City. The NYC DOTT 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.

For each commercial building in New York:



0 1 0 1

0 0 0 0

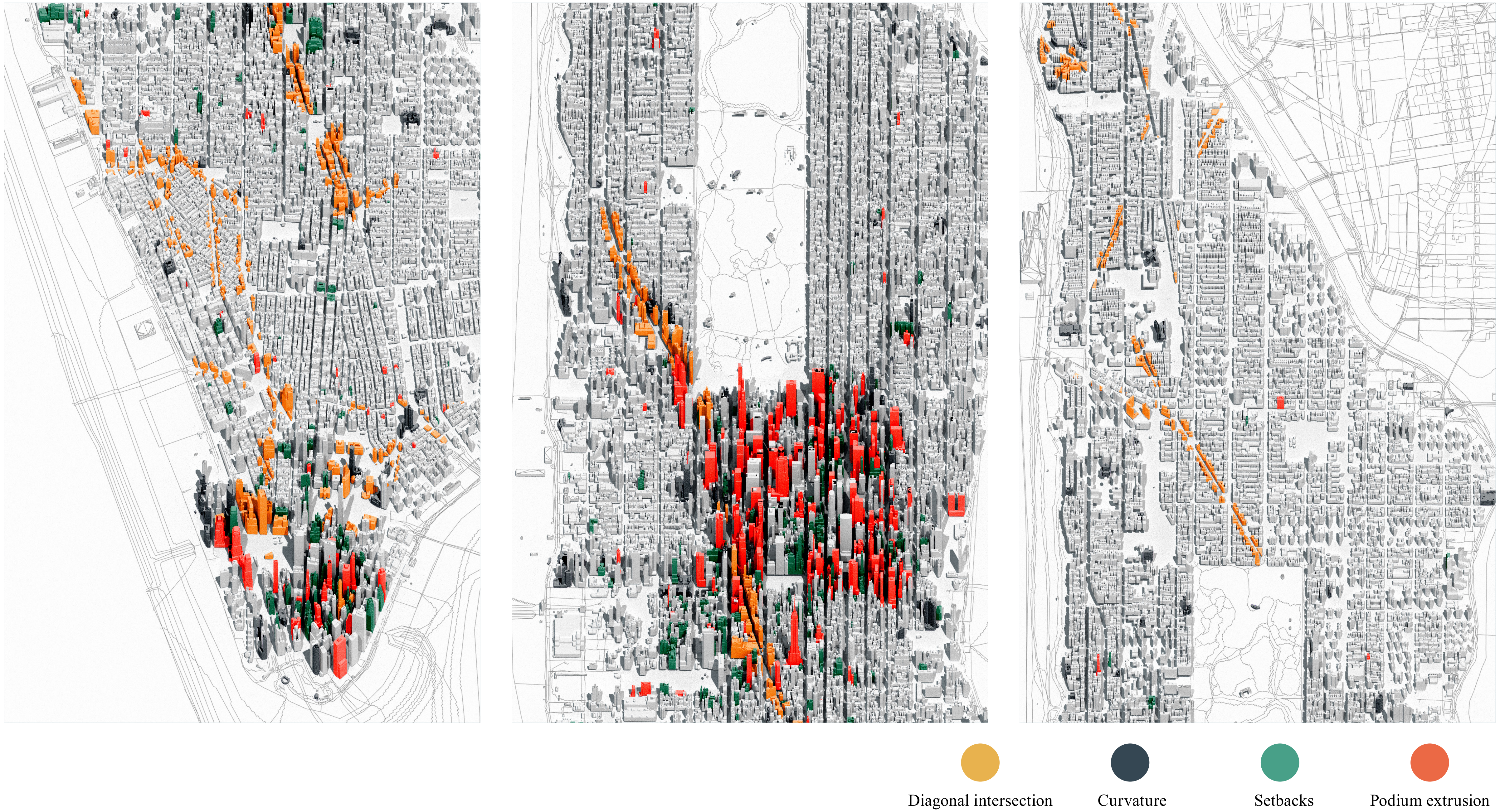
Classifying every commercial building in NYC to create a new design data set

Identifying Design Features

A case study in New York City Manhattan

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 set-backs, and podium extrusion buildings across the city.

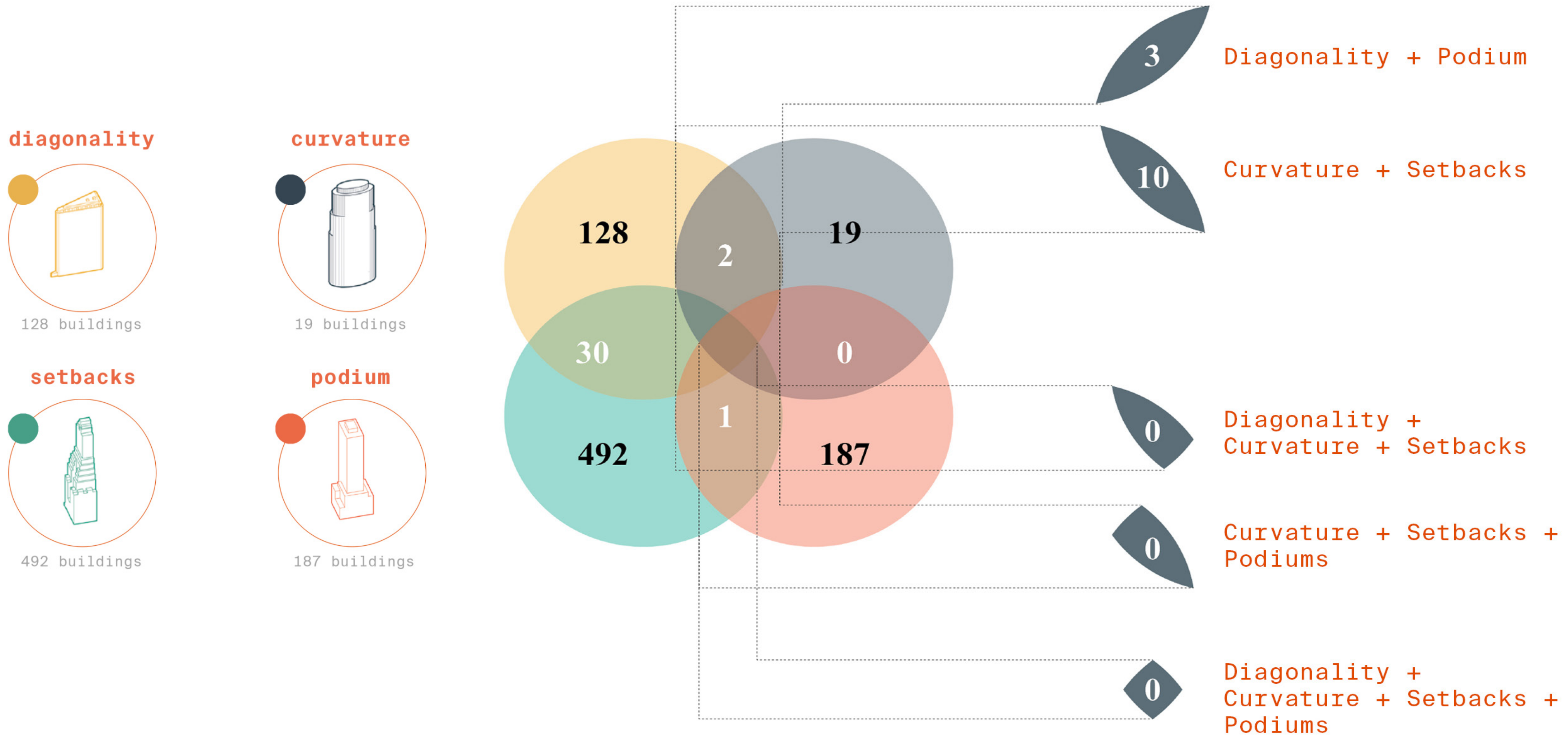


Using a "pure sample" by eliminating overlapping features in the dataset

Eliminating Overlapping Features

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.

- Among 3,141 observations, 161 buildings are located on diagonal roads orintersections, 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.



Using RCA and Compstak data we examine the transaction characteristics of commercial buildings in New York

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 Class C.

Variable	Curvy		Diagonal		Podium		Setbacks		Control Sample		Full Sample	
	Mean	(Std. Dev.)	Mean	(Std. Dev.)	Mean	(Std. Dev.)	Mean	(Std. Dev.)	Mean	(Std. Dev.)	Mean	(Std. Dev.)
Building Information												
logPSM	8.84	(0.61)	8.49	(0.73)	8.67	(0.65)	8.40	(0.60)	8.59	(0.68)	8.56	(0.67)
Price	104,212,982.46	(174,819,999.89)	209,184,989.82	(253,607,070.14)	630,293,650.63	(660,499,245.58)	130,133,036.99	(219,363,640.64)	104,282,214.15	(233,899,588.83)	144,511,287.93	(304,055,153.72)
Age	76.32	(31.88)	79.16	(30.60)	42.35	(26.63)	68.82	(22.31)	81.40	(30.63)	76.92	(30.84)
Number Floors	9.68	(9.80)	19.54	(13.75)	35.72	(15.21)	21.24	(7.90)	14.28	(12.58)	16.87	(13.35)
SqM	16,453.34	(26,204.27)	36,608.05	(34,180.71)	88,090.29	(68,419.35)	25,866.45	(29,406.40)	19,236.95	(34,642.56)	25,152.26	(40,266.14)
Class A	0.47	(0.51)	0.35	(0.48)	0.80	(0.40)	0.42	(0.49)	0.22	(0.42)	0.30	(0.46)
Class B	0.37	(0.5)	0.51	(0.5)	0.17	(0.37)	0.52	(0.50)	0.49	(0.50)	0.47	(0.50)
Class C	0.16	(0.37)	0.14	(0.35)	0.04	(0.19)	0.06	(0.24)	0.29	(0.45)	0.23	(0.42)
Renovated	0.05	(0.23)	0.23	(0.42)	0.24	(0.43)	0.20	(0.40)	0.18	(0.38)	0.19	(0.39)
Walk Score	99.16	(1.64)	99.22	(0.96)	99.10	(1.22)	99.31	(0.73)	99.23	(1.31)	99.23	(1.22)
Buyer Type												
BT Corp	0.05	(0.23)	0.02	(0.12)	0.02	(0.13)	0.06	(0.23)	0.06	(0.24)	0.06	(0.23)
BT Fund	0.00	(0.00)	0.02	(0.15)	0.03	(0.16)	0.02	(0.13)	0.02	(0.15)	0.02	(0.14)
BT Gov't	0.00	(0.00)	0.02	(0.15)	0.02	(0.13)	0.04	(0.20)	0.03	(0.16)	0.03	(0.17)
BT Inst	0.00	(0.00)	0.02	(0.12)	0.04	(0.19)	0.02	(0.15)	0.02	(0.14)	0.02	(0.14)
BT Offshore	0.00	(0.00)	0.05	(0.23)	0.06	(0.25)	0.03	(0.18)	0.03	(0.18)	0.04	(0.19)
BT Private	0.53	(0.51)	0.38	(0.49)	0.25	(0.43)	0.36	(0.48)	0.44	(0.50)	0.41	(0.49)
BT REIT	0.05	(0.23)	0.03	(0.17)	0.10	(0.30)	0.02	(0.13)	0.02	(0.13)	0.02	(0.15)
BT REOC	0.05	(0.23)	0.00	(0.00)	0.03	(0.18)	0.00	(0.00)	0.00	(0.07)	0.01	(0.07)
BT Retailer	0.00	(0.00)	0.01	(0.09)	0.00	(0.00)	0.00	(0.00)	0.00	(0.04)	0.00	(0.04)
BT Unknown	0.32	(0.48)	0.45	(0.50)	0.46	(0.5)	0.45	(0.50)	0.37	(0.48)	0.39	(0.49)
Seller Type												
ST Corp	0.05	(0.23)	0.05	(0.21)	0.04	(0.19)	0.02	(0.15)	0.05	(0.21)	0.04	(0.20)
ST Fund	0.05	(0.23)	0.03	(0.17)	0.02	(0.15)	0.02	(0.13)	0.01	(0.11)	0.02	(0.12)
ST Gov't	0.05	(0.23)	0.02	(0.15)	0.02	(0.13)	0.01	(0.10)	0.03	(0.17)	0.03	(0.16)
ST Inst	0.00	(0.00)	0.02	(0.15)	0.03	(0.18)	0.03	(0.18)	0.02	(0.12)	0.02	(0.14)
ST Offshore	0.00	(0.00)	0.00	(0.00)	0.05	(0.21)	0.04	(0.20)	0.02	(0.14)	0.02	(0.15)
ST Private	0.32	(0.48)	0.15	(0.36)	0.16	(0.37)	0.25	(0.44)	0.32	(0.46)	0.29	(0.45)
ST REIT	0.00	(0.00)	0.02	(0.15)	0.01	(0.07)	0.01	(0.11)	0.01	(0.10)	0.01	(0.10)
ST REOC	0.00	(0.00)	0.00	(0.00)	0.01	(0.07)	0.00	(0.00)	0.00	(0.03)	0.00	(0.03)
ST Retailer	0.00	(0.00)	0.00	(0.00)	0.00	(0.00)	0.00	(0.00)	0.00	(0.05)	0.00	(0.04)
ST Unknown	0.53	(0.51)	0.70	(0.46)	0.67	(0.47)	0.61	(0.49)	0.55	(0.50)	0.57	(0.50)
Leasing Type												
LT CMBS	0.05	(0.23)	0.27	(0.45)	0.38	(0.49)	0.27	(0.44)	0.20	(0.40)	0.22	(0.42)
LT Financial	0.00	(0.00)	0.05	(0.23)	0.02	(0.15)	0.04	(0.20)	0.04	(0.20)	0.04	(0.20)
LT Government Agency	0.00	(0.00)	0.02	(0.12)	0.00	(0.00)	0.00	(0.00)	0.00	(0.05)	0.00	(0.05)
LT Insurance	0.00	(0.00)	0.10	(0.30)	0.12	(0.32)	0.07	(0.25)	0.05	(0.21)	0.06	(0.23)
LT International Bank	0.21	(0.42)	0.13	(0.34)	0.15	(0.36)	0.09	(0.29)	0.10	(0.30)	0.10	(0.30)
LT National Bank	0.16	(0.37)	0.15	(0.36)	0.07	(0.26)	0.14	(0.35)	0.12	(0.33)	0.12	(0.33)
LT Pension Fund	0.00	(0.00)	0.00	(0.00)	0.00	(0.00)	0.00	(0.06)	0.00	(0.04)	0.00	(0.04)
LT Private	0.00	(0.00)	0.00	(0.00)	0.01	(0.10)	0.01	(0.08)	0.02	(0.13)	0.01	(0.12)
LT Regional/Local Bank	0.11	(0.32)	0.08	(0.27)	0.03	(0.18)	0.13	(0.34)	0.15	(0.36)	0.14	(0.35)
LT Unknown	0.47	(0.51)	0.20	(0.40)	0.22	(0.41)	0.26	(0.44)	0.32	(0.47)	0.30	(0.46)
Number of observations	19		128		187		492		2269		3095	

is there a pricing factor on the design features that signals differentiation value for architectural design?

Explaining Transaction Prices

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

Estimation Strategy:

- We estimate a hedonic model, with robust standard errors
- Second, we control for special features of the transaction event such as buyer, seller, and lender types

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).

$$\log P_i = \alpha + \beta X_i + \delta G_i + \varepsilon$$

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.

Does diagonality feature affect price?

Results (1): Diagonality

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 10.8% for the diagonal design feature.
- The results of the models explain between 34 and 48 percent of the transacted price of a building.

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

	(1)	(2)	(3)
Diagonal	-0.044	0.060	0.069
	[0.055]	[0.054]	[0.048]
Location and Transaction Time FE	YES	YES	YES
Building Features FE	NO	YES	YES
Transaction Features FE	NO	NO	YES
Constant	7.764***	7.108***	7.191***
	[0.044]	[0.833]	[0.858]
Observations	2,482	2,397	2,397
R-squared	0.344	0.447	0.496
F Adj R-Squared	0.34	0.44	0.48

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.

Is there a premium associated with curvature?

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 4: Architectural Design Features - Curvature
(Dependent Variable: Logarithm of transaction price per square meter)

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

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.

Does the setback feature affect price?

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 5: Architectural Design Features - Setbacks
(Dependent Variable: Logarithm of transaction price per square meter)

	(1)	(2)	(3)
Setbacks	-0.172***	-0.141***	-0.129***
	[0.026]	[0.027]	[0.026]
Location and Transaction Time FE	YES	YES	YES
Building Features FE	NO	YES	YES
Transaction Features FE	NO	NO	YES
Constant	7.795***	6.832***	6.967***
	[0.042]	[0.806]	[0.824]
Observations	2,862	2,761	2,761
R-squared	0.350	0.450	0.488
F Adj R-Squared	0.34	0.44	0.48

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.

Do buildings with podium extrusion transact with a premium?

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 6: Architectural Design Features - Podium
(Dependent Variable: Logarithm of transaction price per square meter)

	(1)	(2)	(3)
Podium	0.121***	0.138***	0.130***
	[0.041]	[0.046]	[0.045]
Location and Transaction Time FE	YES	YES	YES
Building Features FE	NO	YES	YES
Transaction Features FE	NO	NO	YES
Constant	7.795***	6.720***	6.913***
	[0.044]	[0.821]	[0.834]
Observations	2,544	2,456	2,456
R-squared	0.341	0.443	0.485
F Adj R-Squared	0.34	0.44	0.47

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 (Dependent Variable: Logarithm of transaction price per square meter)

	(1)	(2)	(3)
Diagonal	-0.049	0.040	0.049
	[0.055]	[0.053]	[0.048]
Curvy	0.279***	0.141**	0.159**
	[0.093]	[0.072]	[0.080]
Setbacks	-0.174***	-0.150***	-0.136***
	[0.026]	[0.026]	[0.026]
Podium	0.117***	0.150***	0.146***
	[0.041]	[0.045]	[0.044]
Location and Transaction Time FE	YES	YES	YES
Building Features FE	NO	YES	YES
Transaction Features FE	NO	NO	YES
Constant	7.808***	6.834***	7.017***
	[0.040]	[0.774]	[0.786]
Observations	3,203	3,095	3,095
R-squared	0.347	0.441	0.483
F Adj R-Squared	0.34	0.43	0.47

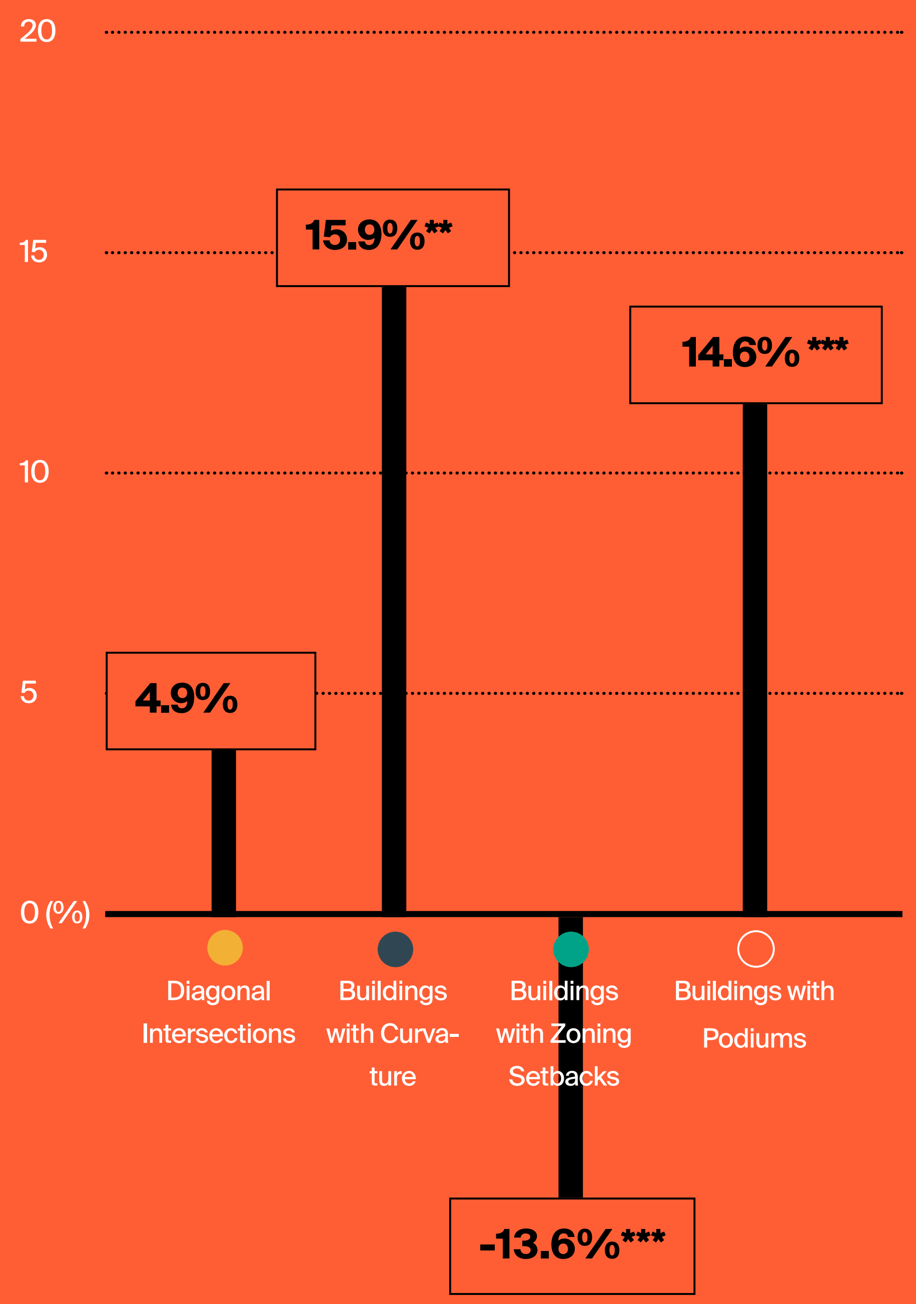
Notes: Robust standard errors in brackets, *** p<0.01, ** p<0.05, * p<0.1. For the sake of purity, we ran the regression for the dataset without any overlapping features. However, if we run the regression for the dataset including the overlapping features, column (3) would yield a positively significant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

results of the hedonic model explain between 33 and 73 percent of the effective rent per square foot

Results Overview

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.



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.

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)

Why might some features yield significant and negative results?

What surprised us?

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

Notable findings:

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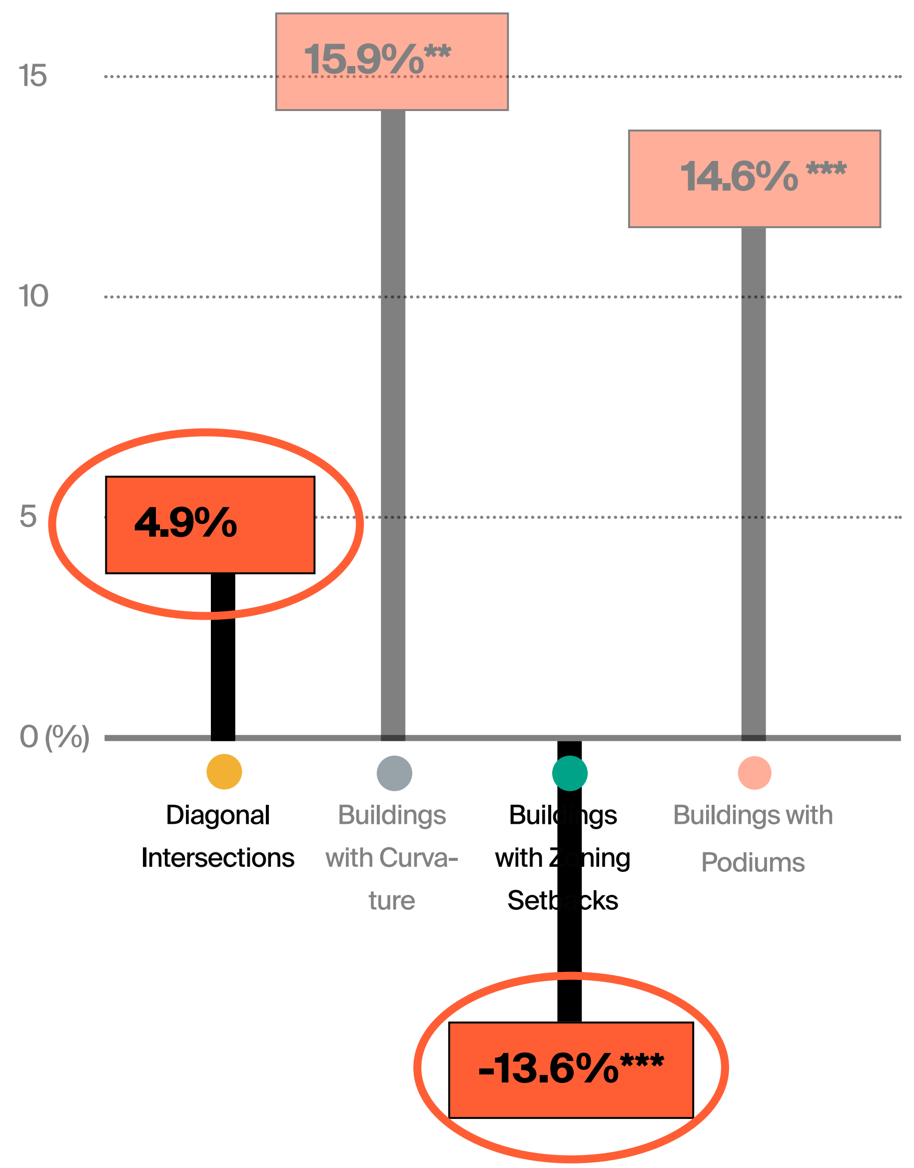

"Although building setbacks are formally similar to podium extrusions, the former has a negative value impact on transaction price for commercial properties while the latter creates a value premium. We speculate this is because the terrace-like form for the upper portion of tall buildings reduces rentable 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

Why designers and developers should both pay attention to this subject

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 nance 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