The Value of Design In Real Estate Asset Pricing

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Abstract

Architects require evidence to justify design interventions of function and form within the financial ecosystem. Some buildings that become real estate assets are valued using models that consider abstract proxies for understanding value, but these features may misidentify differentiation design brings. We investigate the transaction price performance of formal features - curvature, setbacks, podiums and diagonals. Whilst controlling for drivers that are known to explain the price variation, we find that curvature and podiums have a positive pricing differential of 15.9 and 14.6 percent more than the control buildings, respectively. Buildings with setbacks have a negative pricing differential of 13.6 percent. Results suggest there is a significant economic impact of some design interventions that differentiate buildings and requires further research.

Keywords: Architectural Design, Design Precedents, Evaluation, Aesthetics, Asset Pricing

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Highlights

- 826 buildings with architectural design features identified and computed in New York City.
- 3,095 building financial records paired with design features to measure the value of design.
- A review of how design features are valued already by building users and markets
- A review of how architectural design has been measured financially
- Architectural design features differentiate a building's financial value by -13.6 percent to 15.9 percent more.

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Abstract

Architects require evidence to justify design interventions of function and form within the financial ecosystem. Some buildings that become real estate assets are valued using models that consider abstract proxies for understanding value, but these features may misidentify differentiation design brings. We investigate the transaction price performance of formal features - curvature, setbacks, podiums and diagonals. Whilst controlling for drivers that are known to explain the price variation, we find that curvature and podiums have a positive pricing differential of 15.9 and 14.6 percent more than the control buildings, respectively. Buildings with setbacks have a negative pricing differential of 13.6 percent. Results suggest there is a significant economic impact of some design interventions that differentiate buildings and requires further research.

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What are the value drivers for a building? This is an important question for disciplines within the built environment associated with the design and development of buildings, as fifty percent of our building stock is actively traded in the real estate market. Asset valuation models have been steadily improving for the past 50 years to consider real estate value drivers. Predominantly, they are used to understand neighborhood and building feature value impacts. To do so the valuation literature has relied on the hedonic asset pricing model, or some derivation, the hybrid or repeat sales approach (Chegut et al., 2013). Rosen (1974) denoted that the model was intended as a tool to understand product differentiation or variation that led to increased or decreased value in the marketplace. Simply, the model aims to measure the drivers of utility that users are willing to pay for and, when using historical data and a regression, have been shown to pay for. As a statistical tool, it is a multi-variate framework that intends to explain the drivers of a building's price, rent, appraisal value, cost, etc. Although the variables generally used to measure differentiated value are crude and abstract e.g.,building size, age, number of stories, status of renovation, location and proximity to CBD (Chegut et al., 2013), it is the basis behind appraisal analysis and asset valuation econometrics. However, these building and neighborhood features describe only the simplest building elements and its context, which have already been specified as guidelines prior to the design of the physical structure.

Designers, on the other hand, consider much more qualitative and tactile elements of architecture during the design process - such as materiality, geometry, daylight, views and spatial flexibility - to cater to both functional and aesthetic needs. Moreover, design elements, features and characteristics that differentiate buildings are entirely dismissed and overlooked by the current financial practice of commercial real estate valuation, either due to a previous lack of means to collect data about building features, or limited knowledge of the design discipline. However, omitting these features from asset valuation may leave a missed opportunity to understand the extent to which the actual building design features and program impact the property market value and product differentiation during individual real estate transactions. Therefore, we ask, how do design features contribute to building value?

To answer this question, we identify and catalog design features of commercial office buildings and operationalize their geometric measurement using a 3D model of New York City. We construct metrics for four distinct external architectural design elements that relate to transforming a building's design. These design features are diagonal intersections, building curvature, set-backs, and podium extrusions. All of the above, represent design interventions that architects made to differentiate the spatial extrusion of the building in response to regulatory standards and potentially financial constraints. We then pair these building features with realized individual transaction prices in the Manhattan property market from Real Capital Analytics over the 2001 to 2018 period and then compare these to buildings transacted without the four specified design features measured in this paper.

The results of our analysis indicate that there are some design features that demonstrate product differentiation and increased value relative to their market peers. Namely, building curvature and podium extrusions have positive and significant pricing differential relative to their peers of 15.9 and 14.6 percent more, respectively. These results suggest that there is a positive impact of architectural design features that aesthetically and functionally enhance the building. On the other hand, setbacks have a negative pricing differential relative to their building peers of 13.6 percent.

Understanding pricing differentials from design can help align designers and financial decision makers around what creates a long-term value proposition. One may argue that it costs more to execute these design strategies, and unfortunately these data are not systematically collected nor publicly available. However, there remains evidence of a relative value proposition in differentiating the structural design features of the building as evidenced by what building owners were historically willing to pay. In that way, there is a precedent for paying for and justifying the value of design.

The remainder of this paper is laid out as follows. In section two, we outline the literature that looks at the real estate valuation for commercial buildings as well as prior research on design value. In section three, we outline the design elements we developed for this paper. We then select four external architectural design features for further investigation. In section four, we document our dataset, descriptive statistics and geographical characteristics. In section five, we outline our hedonic methodology. In section six, we document our results. In section seven, we discuss what these results mean for design practice and the real estate valuation literature.

1. Valuing Design: a Review

In general, there is limited literature that measures architectural design features rather than involvement of awarded architects. Current research identifies market response to design awards as a measure of architectural design quality which can have financial value. Important architectural projects as represented by awarded designers may generate a real estate value premium (Hough & Kratz, 1983; Vandell & Lane, 1989; Millhouse, 2005; Fuerst et al., 2009; Nase et al., 2016; Kang, 2019) and may perform as a positive externality for nearby building valuations (Ahlfeldt & Mastro, 2012). Common practice to measure architectural quality and assess how design differentiates involves using a hedonic pricing model, and conducting surveys, interviews and expert-led grading (Vandell & Lane, 1989; Millhouse, 2005; Rahadi et al., 2013; Nase et al., 2016).

In their seminal work, Hough and Kratz (1983) document the economic impacts of architectural design in commercial buildings for buildings in the CBD of Chicago and focused on the designation of a building as a landmark, and(or) award-winning status with value premiums.[1] Asabere et al.,(1989) focused on historical architecture and categorized the samples into architectural styles - colonial, federal, garrison, and Victorian architectural styles - townhouse, duplex, condominium, and ranch housing styles in order to detect economic impacts of architecture style on home value. Plaut and Uzulena (2005) conducted similar research in Riga, Latvia by studying buildings from different time periods. Buitelaar and Schilder (2017) also looked

[1]Other attributes that they were able to be quantifiably measure, such as the radial distance of an office building from the CBD, building age, total gross floor area, number of floors and the presence of a restaurant.

into architectural styles but included many specific characteristics in their hedonic price model - plot size, construction year, dwelling type, parking type, and land lease condition, thereby controlling for design value more closely.

Another approach has been to look at awarded designers. Cheshire and Derick (2014) and Fuerst, McAllister, and Murray (2009) focused on architectural projects by the Pritzker Prize and/or AIA Gold Medal winning architects in the USA. Both papers found evidence of correlation between buildings by award-winning architects and their economic value but, the research did not scrutinize the impacts of other aspects of architectural design and attributed the additional economic value to the reputation of famous architects. So-called "Good" architecture, be it an award-winning project, a project designed by a famous architect, or a building with high ratings from experts, may bring significant value premiums (Hough & Kratz, 1983; Vandell & Lane, 1989; Millhouse, 2005; Fuerst et al., 2009; Nase et al., 2016; Kang, 2019).

Few researchers have attempted to identify the term "design," with one exception, Lindenthal (2017) who documents a hedonic pricing relationship between design form homogeneity for residential houses in Rotterdam, the Netherlands, where heterogenous or differentiating housing forms earned a discount. People's interpretation of design works are likely to involve the communicative intentions embedded in those designs (Crilly et al., 2008). Different combinations of individual design attributes are likely to shape viewers' perception of design style (Chan, 2000) or recognition of the overall image (Ranscombe et al., 2012). To further understand the value of design, thus, requires research to identify and quantify design attributes for in-depth valuation. Architectural form is an important place to start.

2. Identifying Design Features

Nascent research in this field took "design" as an explicit subject of the architect, mainly his(her) prowess or measured accomplishments, without looking into the underlying features of design. Early work in this domain is provided by Ching (1979) who deconstructs architectural design into compositional features through an analysis of form, space, and spatial order. "As an art, architecture is more than satisfying the purely functional requirements of a building program. Fundamentally, the physical manifestations of architecture accommodate human activity. However, the arrangement and ordering of forms and spaces also determine how architecture might promote endeavors, elicit responses, and communicate meaning (Ching, 1979)." While examining and illustrating abstract concepts of design, such as point, line, and plane, Ching devoted extensive effort into categorizing formal elements - surface, primary solids, and openings with planes - or elements that may shape directly a building's form - linear organization, structural proportion, and configuration of the path, just to name a few. Similarly, Ching (1995) focuses on providing extensive illustrations of key terms used in architectural practice.

This line of research is also explored by Koolhaas et al. (2014) where architecture fundamentals are dissected into fifteen primary components, such as wall, floor, ceiling, corridor, and facade, just to name a few. Bille and Sorensen (2016) focused more on the conceptual, atmospheric aspects of design. These studies understood architecture as integration of tangible and intangible elements that are related to materiality and historical meanings.

One way we have advanced across domains is in computation. In the valuation practice in real estate, methodologies currently used to observe and evaluate the built environment are based on the data available from transaction prospectus or rent contracts, which presents only a minuscule fraction of the large data sets and features we are equipped to gather. In contrast, we identify and construct a new set of data on design metrics to provide reference and guidelines for both designers and developers for some external architectural design elements.

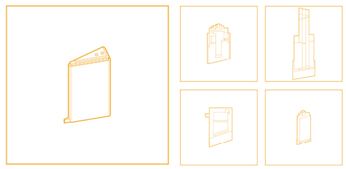
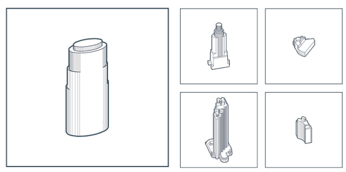
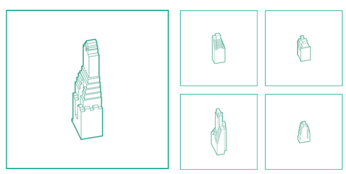
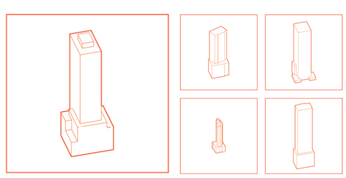
Considering both the internal and external design features that are outlined by Ching (1995) and Koolhaas et al. (2014) there are extensive design features that can be potentially measured inside and outside of the building. Internal design metrics require comprehensive floor-plans and sections details of each building which are currently scattered across individual architecture firms, inconsistently collected by the planning authority and unavailable to collect for many properties.[2]

We focused on individual features of external building form. The selected design metrics may produce noticeable changes on the exterior of buildings, hence significantly shaping the overall building design and differentiation of the structure relative to its peers. The four metrics are diagonal intersections, curvature, setbacks and podium extrusions. They are detailed further in Figure 1. First, the sites of buildings that sit on diagonal road intersections usually have a unique geometry, which would require architectural designers to come up with alternative design solutions involving use of non-90-degree angles.[3] Second, we see curvature as a design feature which might make the buildings more iconic than buildings without significant exterior features. In addition, the presence of curvature may also reflect the developer and designer's effort to create a leading real estate product in the market, creating iconicity at the cost of higher construction price. The third feature is the setback feature. The city's 1916 Zoning Resolution forced buildings to push back from the street above a certain height to ensure the access of light and air from the street level. As a result, designers had to design a terrace-like form for the upper portion of many buildings, hence creating a geometry that is different from other buildings. This has led to the later development of the podium, which as a design feature was meant to meet strict zoning requirements, while embracing alternative mixed-use commercial space for retail needs on the bottom floor.

[2]However, it is important to consider in the design catalogue as commercially available reality capture technology can help document the details of every physical space in a building.

[3]Although the Flatiron building is famous for dealing with land constraints, it is actually not a unique building in Manhattan. There are 167 buildings that respond to diagonal intersections with non-rectangular forms.

Figure 1: External Architectural Design Features

Name	Design Examples	Description
Diagonal intersection		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.
Curvature		Buildings with calculated non-90 degree envelope features in 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		Building with a terraced form in the upper part of the structure. 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. Even during periods when the 1916 Zoning Regulation became inactive, some designers still chose to reproduce the terrace-like form for high-rises.
Podium extrusion		Buildings with a horizontal base on the lower floors of the structure. Podium extrusion 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 extrusion. Some recent design, such as the Heart Tower, Beekman Tower, Hampshire's Dream Hotel (under construction), also included podiums. Podium extrusion 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 mix-use complex.

Notes: Figure 1 documents the descriptive elements of four external design features, diagonal intersection, curvature, setbacks and podium extrusions and some design examples.

2.1. *Diagonal Intersection*

The 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" (Grant, 2001).Since "straight-sided and right-angled houses were the least expensive to build and most convenient to live in" according to the city commissioners, grids were intended to maximize the value of real estate and make the division of land into saleable lots more easily (Goldberger, 2001). The grid laid out 155 east-west streets and twelve north-south avenues, halting at 155th street due to challenging ground conditions. Two elements stood out as exceptions to the rule: Central Park and Broadway were foreign elements that disrupted the regularity of the grid and confused traffic.[4] However, the legacy of this tension is production of 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. [5]

2.2. *Curvature*

In general, the way curvilinearity affects human perception has been studied widely across scales in the built environment: from products' graphics and container designs (Westerman et al., 2012), to cars (Leder & Carbon, 2005), to architectural interiors (Vartanian et al., 2013). Scholars have long studied the relationship between curvilinearity and form, from the perspective of psychology, philosophy, evolution and aesthetics (Hogarth, 1753; Spencer, 1873; Allen, 1877; Santayana, 1896; Valentine, 1913). More generally, curved lines have often been considered as "more harmonious, relaxing, or pleasant – and more in consonance with nature than straight or broken lines" (Gómez-Puerto et al., 2016).[6] In architectural theory, organic architecture claims that free-flowing form is more compatible to the human body (Pearson, 2001) and buildings which share formal qualities with natural forms are subconsciously and psychologically perceived as more comfortable (Salingaros, 1998).[7]

In research emerging from fields of environmental science, Shepley's comparison of two different interior environments show that people of various ages more frequently prefer curved walls as object-orienting spaces as opposed to square-off walls as spatially-orienting spaces (Shepley, 1982). Vartanian et al. have conducted an fMRI study where participants responded to images of interior architectural spaces with various degrees

[4] Broadway was originally a Native American footpath called the Wickquasgeck Trail traversing the length of Manhattan, which became a main north-south road through the island after the Dutch founded New Amsterdam at the southern tip of Manhattan in 1626 (American Planning Association, 2014).

[5] Squares such as Union Square at 14th Street, Madison Square Park at 23rd Street, Herald Square at 34th Street, Times Square at 46th Street, and Columbus Circle at 59th Street (Davis, 2010). As a result, these portions of the Broadway have become popular destinations for strolling during both day and night (Okamoto & Williams, 1969).

[6] Pythagoras studied the beauty of architecture by assessing the mathematical relationship between a building and its constituent architectural elements (Murphy & Kovach, 1972).

[7] Along this lineage, Madani (2007) studies the "affective" and "interpretive" assessments of curvilinearity in the interior built environment using approaches outlined by Gifford et al. (2000) and methods used by Delvin and Nasar (1989).

of curvature and sharp angles. The study found rooms with curved spaces to be subjectively preferred overall (Vartanian et al., 2013). From a psychological perspective, various degrees of curvature could induce different feelings from the observer. A Hopkins' study from 1976 created four categories of line segments for judging the amount of curvature based on curve radii (Hopkins et al., 1976). While a straight line generates minimal attraction, data shows that too much curvature makes the participant experience feelings of confusion and anxiety (Roelfsema et al., 1999).

2.3. Setbacks

According to Ely Jacques Kahn 1926, "The New York zoning laws protecting property rights, light, and air have encouraged a new art by reason of the very restrictions they contain." Passed by the City's Board of Estimate on July 25, 1916, the zoning ordinance applied the principle of the zoning envelope to all commercial high-rise buildings. Five formulas that were based on the width of the street and the angle of the setback were used to define the physical envelope of a building.[8] The numerous permutations of the formula provided by different width of the street encouraged the "wedding cake" setbacks. The shape of the building was effectively pre-designed by code (Willis, 1995).

By the mid-1920s, a number of architects and critics were writing about a new design approach which some labeled the "setback style" (Willis, 1986). Pioneering projects such as the Shelton Hotel and the Barclay-Vesey Telephone Building became the benchmark of progressive design by simplifying the number of setbacks and emphasizing the power of simple, sculptural, and pyramidal mass (Haskell). Architect Harvey Wiley Corbett and delineator Hugh Ferriss added the programmatic influence of the setback by elaborating the utilization of the upper levels being an additional effect of stepping back the building. Increased privacy, exposure, light and air, as well as use of an outdoor space were the inherent advantages identified in the new "setback style" (Ferriss, 1929).

2.4. Podium Extrusion

A classical skyscraper consists of a base, a shaft and a crown, which is a morphology that has emerged in the 1920's. According to the Skyscraper Dictionary created by Dutch economist Jan Klerks, a podium is distinct from a base 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. In order to assist developers and architects in designing tall buildings, numerous cities provide tall building guidelines to establish standards

[8] According to Commission on Building Districts and Restrictions, the five basic formulas were: (1) 1 X width of street = 1ft, setback: 2ft, vertical rise; (2) 1.25 X width of street = 1ft, setback: 2.5ft, vertical rise; (3) 1.5 X width of street = 1ft, setback: 3ft, vertical rise; (4) 2 X width of street = 1ft, setback: 4ft, vertical rise; (5) 2.5 X width of street = 1ft, setback: 5ft, vertical rise.

and recommendations where the podium of a tall building "anchors the tower and defines pedestrian experience at the street level...[in which its] location and height should frame and create a positive relationship to the street" (Brook McIlroy, 2017).[9]

3. A Geometric, Geospatial and Relational Dataset

First, to assess the external architectural differentiation of the city, we need to examine the geometry of New York City.[10] We then classify the geometry of every building in the city, according to our four external architectural features. Using the 3D model of NYC, we assign a dummy variable of 1 to each building if it has a design feature, and 0 otherwise. Some buildings may have more than one design feature. Figure 2 depicts the Manhattan building geometry in 3D and isolates the diagonal intersections, building curvature, setbacks, and podium extruded buildings across the city. We find that there is concentration of buildings with podium extrusions in Midtown and Downtown Manhattan, whereas buildings located on diagonal intersections are spread throughout NYC. Similarly, buildings with curvature in their exterior envelope are distributed across the city.

We then pair the building geometry of our selected sample to their geolocational attributes using New York City's geocoding tool, GeoBat, to identify unique building identification numbers (BIN). We then match the BIN of the 3D models with our building dataset and assign a variable to each of the design metrics.

Finally, we use commercial building transaction data provided by Real Capital Analytics (RCA) and feature data from Compstak to provide fundamental hedonic variables for our pricing model and test the model in New York City. [11] [12] We extract location and transaction time data for individual property transactions from the RCA dataset to control for time and location. We then extract the Building Class feature for each building that transacted from the Compstak dataset to control for the overall quality of the buildings in the sample dataset and match the observations from the RCA dataset. In addition to these two datasets, we include a Walk Score variable from Walkscore.com to measure the walkability of a neighborhood and its accessibility to public transit with a score range from 0.00 to 100. In total, we have the complete database for all the variables for 3,141 observations for commercial real estate in Manhattan over the 2001 to 2018 period.

[9]Brook McIlory emphasizes the importance of creating a connection between the public and private realm through the podium, while ensuring vibrancy throughout the day.

[10]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.

[11]RCA specializes in property transaction data in New York City and provides building transaction data that includes financing details, prior transaction history, and true owner identification.

[12]Compstak provides crowdsourced information such as lease contract characteristics, tenant profile, and market variables from verified professionals from commercial brokerage and appraisal firms.

Figure 2: Geographic Variation of External Architectural Design Features

Figure 2 depicts the geographic variation of external architectural design features - diagonal intersection, curvature, setbacks and podium extrusions in Manhattan, New York.

Table 1: Building Characteristics by Geometry

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	

Notes: Table 1 highlights the mean and variation of building characteristics for the building samples with curvature, site location on a diagonal intersection, podium, and the New York City setback geometry.

3.1. Descriptive Statistics

Table 1 shows the dependent and independent variables included in the analysis and compares the average characteristics of buildings with visible external design features with that of control samples. Buildings with measured design features yielded higher average transaction prices compared to the control samples. Buildings with podium extrusions yielded an unusually high average transaction price and high price variability. However, the price variability of buildings with other design features is generally lower than that of 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. All building samples have similar walk scores due to the high connectivity of Manhattan's unique urban environment.

Our samples indicate that most buyers (41 percent) are real estate private companies. Such a trend remains consistent across building samples with design features and the control samples. In particular, 53 percent of buyers of buildings with curvature are also private companies. Even if buildings with podium extrusion have only 25 percent of buyers that are private companies, the percentage remains as the largest. In general, none of the buildings with design features or control buildings have attracted many buyers from any specific buyer type besides private companies.

Private companies are also the largest sellers of both buildings with design features and control buildings samples. 32 percent of buildings with curvature are sold by private companies, same as the 32 percent of control buildings sold by private companies. However, the percentages of sellers from private companies in buildings with other features are noticeably lower than the former two - 15 percent for buildings at a diagonal intersection, 16 percent for buildings with podium extrusion, and 25 percent for buildings with setbacks.

As for lending types, our sample shows that buildings with curvature have a combination of leasers in four categories - CMBS, International Bank, National Bank, and Regional/Local Bank. The control buildings also have a similar mix of leasers. However, buildings with other design features have a particularly high concentration of leasers from CMBS and, in general, a relatively small concentration in Regional/Local Bank.

Among 3,141 observations, 161 buildings are located on diagonal roads or intersections, 31 buildings have curvature, 533 buildings have setbacks, and 191 buildings have podium extrusion. Indeed, some buildings contain more than one design feature. As shown in Figure 3, 30 buildings have both setbacks and diagonal intersections; 2 buildings have curvature and diagonal intersection; 1 building has setbacks and podium extrusion; 3 buildings are at diagonal intersections and have podium extrusion; 10 buildings have curvature and setbacks. From there, we may re-group 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. 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.

Figure 3: Overlaps of Design Features

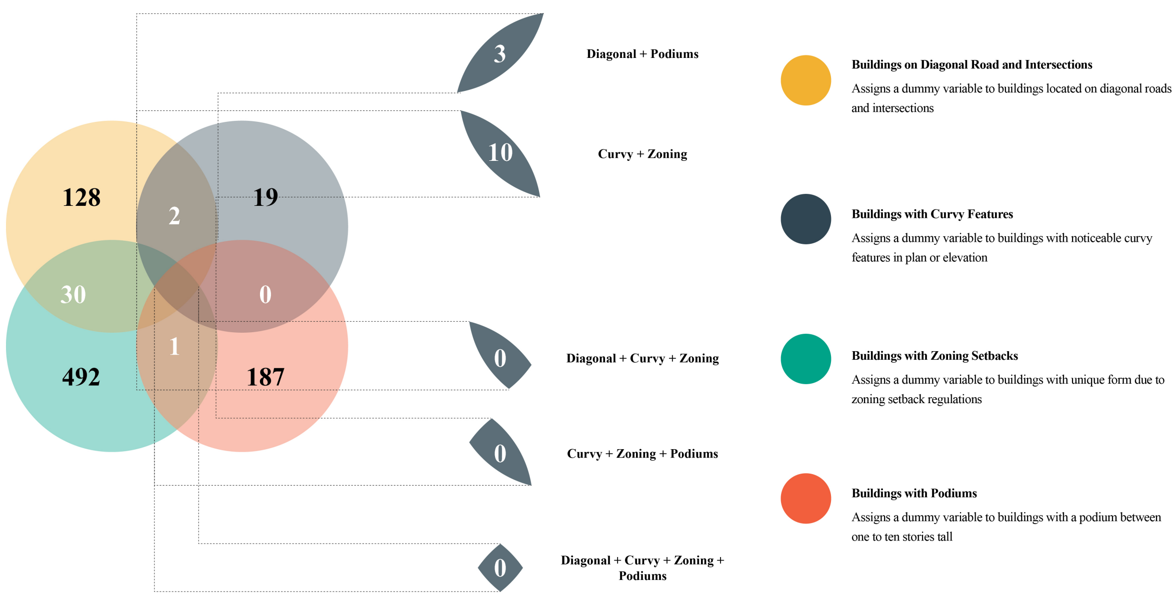


Figure 3 documents the overlaps of design features in our data set.

4. Methodology

In this study, we employ the hedonic pricing method to analyze and understand commercial real estate pricing dynamics. The hedonic pricing method captures the impact on asset pricing of both internal and external characteristics of a property, allowing an analysis of a cross-sectional dataset and measurement of design features in the real estate marketplace. However, while New York City has a rich database in the built environment, little information exists on the subject of design, especially on design features examined from an architectural perspective. A key contribution of this research is the construction of a design dataset that begins to measure design characteristics, which may serve as support or guide to the designer's future work as design becomes increasingly important in development projects.

To measure the impact of external design features we operationalize the control samples a semi-log model to understand the impact of external architectural design features with Equation 1 outlined here:

$$logP_i = \alpha + \beta X_i + \delta G_i + \varepsilon_i, \tag{1}$$

where the dependent variable is the logarithm of the transaction price P in commercial office buildings i. X is a vector containing a list of hedonic characteristics of buildings i and G is a vector of a list of design feature variables with the value of 1 if building i falls into the category of design metric we specified, and 0.00 otherwise. α is a constant while β and δ are estimated coefficients and ϵ is an i.i.d. error term.

5. Results

Employing equation (1) we estimate the impact of external architectural design features upon the logarithm of building transaction prices. The results of the models explain between 34 and 48 percent of the transacted price of a building. Table 2 documents the results for rectilinear structures in NYC, in columns (2-5) we document the impact of each design feature. In column 6 we document the results of design features relative to control buildings.

Table 2: Architectural Design Features - Control Sample (with None of Design Features), Diagonal Intersection, Curvature, Setbacks, Podium and Full Sample (with All Design Features)
(Dependent Variable: Logarithm of Transaction Price per Square Meter)

	(1) Control Sample	(2) Diagonal	(3) Curvature	(4) Setbacks	(5) Podiums	(6) Full Sample
Design Metrics						
Diagonal Intersections		0.069				0.049
		[0.048]				[0.048]
Curvature			0.137*			0.159**
			[0.082]			[0.080]
Setbacks				-0.129***		-0.136***
				[0.026]		[0.026]
Podium Extrusions					0.130***	0.146***
					[0.045]	[0.044]
Building Features						
Age	-0.007***	-0.008***	-0.007***	-0.007***	-0.006***	-0.007***
	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]
Number Floors	0.002*	0.001	0.002*	0.002**	0.003**	0.003**
	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]
Log(SqM)	-0.161***	-0.158***	-0.162***	-0.156***	-0.157***	-0.151***
	[0.010]	[0.010]	[0.010]	[0.009]	[0.010]	[0.009]
Class B	-0.131***	-0.123***	-0.131***	-0.100***	-0.160***	-0.116***
(Relative to Class A)	[0.030]	[0.029]	[0.029]	[0.025]	[0.029]	[0.024]
Class C	-0.173***	-0.160***	-0.174***	-0.150***	-0.195***	-0.158***
(Relative to Class A)	[0.034]	[0.033]	[0.034]	[0.031]	[0.033]	[0.029]
Renovated	0.051*	0.061**	0.053*	0.072***	0.055**	0.082***
	[0.030]	[0.028]	[0.030]	[0.026]	[0.028]	[0.024]
Walk Score	0.025***	0.023***	0.024***	0.025***	0.026***	0.024***
	[0.009]	[0.009]	[0.009]	[0.008]	[0.008]	[0.008]
BT Relative to BT Private						
BT Corp	-0.113**	-0.122**	-0.108**	-0.094**	-0.108**	-0.093**
	[0.051]	[0.050]	[0.050]	[0.046]	[0.050]	[0.044]
BT Fund	0.251***	0.244***	0.253***	0.267***	0.263***	0.276***
	[0.071]	[0.068]	[0.071]	[0.064]	[0.067]	[0.059]
BT Gov't	-0.117*	-0.147**	-0.112*	-0.123**	-0.117*	-0.135**

Table 2 **Architectural Design Features:**(Continued on next page ...)

Table 2 —- : (Continued from previous page)

	(1) Control Sample	(2) Diagonal	(3) Curvy	(4) Setbacks	(5) Podium	(6) Full Sample
	[0.064]	[0.063]	[0.064]	[0.055]	[0.061]	[0.053]
BT Inst	0.227***	0.237***	0.229***	0.201***	0.206***	0.196***
	[0.052]	[0.051]	[0.052]	[0.047]	[0.052]	[0.047]
BT Offshore	0.280***	0.291***	0.283***	0.275***	0.271***	0.284***
	[0.060]	[0.057]	[0.060]	[0.055]	[0.053]	[0.048]
BT REIT	0.949***	0.938***	0.949***	0.933***	0.968***	0.947***
	[0.075]	[0.074]	[0.075]	[0.071]	[0.072]	[0.067]
BT REOC	-0.036	-0.048**	-0.033	-0.030	-0.032	-0.033
	[0.024]	[0.023]	[0.024]	[0.022]	[0.023]	[0.021]
BT Retailer	0.241***	0.240***	0.236***	0.207***	0.200***	0.177***
	[0.078]	[0.073]	[0.077]	[0.071]	[0.063]	[0.055]
ST Relative to ST Fund						
ST Corp	0.109**	0.126**	0.111**	0.066	0.154***	0.127***
	[0.051]	[0.049]	[0.051]	[0.049]	[0.051]	[0.047]
ST Gov't	0.314***	0.337***	0.301***	0.304***	0.279***	0.289***
	[0.094]	[0.086]	[0.091]	[0.078]	[0.085]	[0.067]
ST Inst	0.098*	0.115*	0.091	0.078	0.102*	0.091
	[0.059]	[0.060]	[0.058]	[0.055]	[0.057]	[0.056]
ST Offshore	0.179***	0.212***	0.178***	0.202***	0.174***	0.220***
	[0.069]	[0.066]	[0.069]	[0.057]	[0.065]	[0.053]
ST Private	0.332***	0.332***	0.332***	0.284***	0.293***	0.266***
	[0.056]	[0.056]	[0.056]	[0.052]	[0.062]	[0.055]
ST REIT	0.107***	0.109***	0.104***	0.098***	0.112***	0.102***
	[0.027]	[0.026]	[0.026]	[0.024]	[0.026]	[0.023]
ST REOC	0.172	0.200*	0.171	0.162*	0.145	0.169*
	[0.122]	[0.113]	[0.122]	[0.098]	[0.116]	[0.090]
ST retailer	0.173	0.197	0.176	0.155	0.351**	0.347**
	[0.149]	[0.143]	[0.150]	[0.126]	[0.150]	[0.144]
LT Relative to LT Private						
LT CMBS	0.116***	0.125***	0.117***	0.089***	0.127***	0.112***
	[0.034]	[0.033]	[0.034]	[0.030]	[0.032]	[0.028]
LT Financial	0.115**	0.114**	0.116**	0.042	0.107**	0.042

Table 2 **Architectural Design Features:**(Continued on next page ...)

Table 2 —- : (Continued from previous page)

	(1) Control Sample	(2) Diagonal	(3) Curvy	(4) Setbacks	(5) Podium	(6) Full Sample
	[0.046]	[0.046]	[0.046]	[0.045]	[0.047]	[0.046]
LT Government Agency	-0.215**	-0.075	-0.213**	-0.220**	-0.217**	-0.087
	[0.093]	[0.110]	[0.092]	[0.094]	[0.092]	[0.104]
LT Insurance	-0.177***	-0.230***	-0.175***	-0.134**	-0.153***	-0.159***
	[0.063]	[0.061]	[0.063]	[0.053]	[0.058]	[0.049]
LT International Bank	0.013	0.001	0.016	0.012	0.004	-0.003
	[0.037]	[0.036]	[0.036]	[0.034]	[0.036]	[0.033]
LT National Bank	-0.078**	-0.078**	-0.073**	-0.073**	-0.082**	-0.071**
	[0.037]	[0.036]	[0.037]	[0.033]	[0.036]	[0.031]
LT Pension Fund	0.006	-0.001	0.007	0.070	-0.015	0.079
	[0.520]	[0.514]	[0.522]	[0.321]	[0.536]	[0.326]
LT Regional/Local Bank	-0.132***	-0.143***	-0.131***	-0.151***	-0.133***	-0.157***
	[0.034]	[0.034]	[0.034]	[0.031]	[0.034]	[0.031]
Location and Time FE	YES	YES	YES	YES	YES	YES
Constant	7.069***	7.191***	7.090***	6.967***	6.913***	7.017***
	[0.864]	[0.858]	[0.855]	[0.824]	[0.834]	[0.786]
Observations	2,269	2,397	2,288	2,761	2,456	3,095
R-squared	0.494	0.496	0.496	0.488	0.485	0.483
F Adj R-Squared	0.48	0.48	0.48	0.48	0.47	0.47

Robust standard errors in brackets

*** p<0.01, ** p<0.05, * p<0.1

Notes: Robust standard errors in brackets, *** p<0.01, ** p<0.05, * p<0.1.

Column (1) of Table 2 documents the impact of location, time, building features such as age, number of floors, size, building class, status of renovation and Walk Score, transaction features such as buyer type, seller type and lender type, for the control samples in the dataset, which are buildings without any of the four design features.

Column (2) of Table 2 documents the impact of diagonality on transaction prices for the control sample observations and buildings located on diagonal roads or intersections, with controls for location, time, building and transaction features. Column (2) of Table 2 yields a result of 6.9 percent positive and statistically insignificant coefficient for diagonal intersections. Results show that 48 percent of the variation in the logarithm of transaction price per square meter is explained by location, time, building and transaction features. Table 3 from the Appendix shows the full documentation of the controls for fixed effects. In column (1) of Table 3, we document controls for location and transaction time; column (2) of Table 3 documents the addition of building features such as age, number of floors, building area, land parcel area, building class, year of renovation and Walkscore; in columns (3) we assess transaction features such as who is the buyer, seller and lender in the transaction. After controlling for the fullest specification of the model, we document that buildings located on diagonal roads or intersections do not transact more or less than buildings located on regular orthogonal street grids.

Column (3) of Table 2 documents the impact of curvature on transaction prices for the control sample observations and buildings with curvature. Column (3) of Table 2 yields a result of 13.7 percent positive and significant coefficient for curvature. Results show that 48 percent of the variation in the logarithm of transaction price per square meter is explained by location, time, building and transaction features. Table 4 from the Appendix shows the full documentation of the controls for fixed effects. In column (1) of Table 4, we document controls for location and transaction time; column (2) of Table 4 documents the addition of building features such as age, number of floors, building area, land parcel area, building class, year of renovation and Walkscore; in columns (3) of Table 4 we assess transaction features such as who is the buyer, seller and lender in the transaction. After controlling for the fullest specification of the model, we document that buildings with curvature account for 13.7 percent more than those buildings with no curvature, with a positive and significant coefficient.

Column (4) of Table 2 documents the impact of setbacks on transaction prices for the control sample observations and buildings with setbacks. Column (4) of Table 2 yields a result of 12.9 percent negative and significant coefficient for setbacks. Results show that 48 percent of the variation in the logarithm of transaction price per square meter is explained by location, time, building and transaction features. Table 5 from the Appendix shows the full documentation of the controls for fixed effects. We estimate the same models as those represented in Tables 3 and 4. After controlling for the fullest specification of the model, we document that buildings with setbacks account for 12.9 percent less than those buildings with no building setbacks, with a negative and significant coefficient.

Column (5) of Table 2 documents the impact of podium extrusion on transaction prices for the control sample observations and buildings with podium extrusion. Column (5) of Table 2 yields a result of 13.0 percent positive and significant coefficient for podium extrusion. Results show that 47 percent of the variation in the logarithm of transaction price per square meter is explained by location, time, building and transaction features. Table 6 from the Appendix shows the full documentation of the controls for fixed effects. We estimate the same models as those represented in Tables 3, 4 and 5. After controlling for the fullest specification of the model, we document that buildings with podium extrusions account for 13.0 percent more than those buildings with no podium extrusions, with a positive and significant coefficient.

Column (6) of Table 2 documents the impact of building location on diagonal intersection, curvature, setbacks, and podium extrusion on transaction prices for all the observations. Column (6) of Table 2 yields a result of 4.9 percent positive and insignificant coefficient for diagonal intersection, 15.9 percent positive and significant coefficient for curvature, 13.6 percent negative and significant coefficient for setbacks, and 14.6 percent positive and significant for coefficient for podium extrusion. Results show that 47 percent of the variation in the logarithm of transaction price per square meter is explained by location, time, building and transaction features. Table 7 from the Appendix shows the full documentation of the controls for fixed effects. We estimate the same models as those represented in Tables 3, 4, 5 and 6. After controlling for the fullest specification of the model, we document that buildings located on diagonal roads or intersections do not transact more or less than buildings located on regular orthogonal street grids; buildings with curvature are transacted for 15.9 percent more than buildings with pure rectangular geometry; buildings with setbacks are transacted for 13.6 percent less than those buildings without setbacks; buildings with podium extrusions are transacted for 14.6 percent more than buildings without podium extrusions.

6. Discussion and Conclusion

We examine the impact of architectural design features upon building valuation. Distinct from the current design valuation literature, we measure architectural form at a feature level to assess the impact of external architectural form on transaction price. Importantly, disassociating design as part of a cohort of various architectural styles or as functional components, such as the number of floors, inclusion of amenities, or views to the exterior, this study attempts to understand the relationship between architectural form and real estate value. After controlling for building features, contract features, location and transaction time and other features included in past research. We find that architectural form decisions can have a statistically and economically significant impact on the value of buildings.

The fundamental challenge of assessing the impact of an isolated variable is to control for other exogenous and omitted variables that also determine the transaction price. For that, we used a hedonic price model. After controlling for building and neighborhood features, these models explained 48 percent of the variation in price per square foot, but when looking solely at the price explain around 80 percent of the variation in price. This differential suggests the outsize impact that building size and variation has on the value of assets and makes these results more conservative than the real estate asset valuation literature.

Two design features yielded positive impacts on transaction price - curvature and podium extrusion. These design features shaped the exterior appearance of buildings. Curvature and podium extrusion were estimated to have a 15.9 percent and 14.6 percent transaction price premium, respectively, relative to buildings without these features. Both the curvature feature and the podium extrusion feature yielded positive and significant impact on transaction price. On the other hand, buildings whose footprints are non-90-degree angles as result of locating on diagonal roads or intersections do not appear to have a transaction premium than buildings located on orthogonal street grids.

However, setbacks returned a statistically significant and negative result. Initially, we understood this design feature as a result of the new zoning law implemented in 1916, which forced buildings to push back from the street above a certain height to ensure the access of light and air from the street level, adopting a terrace-like form for the upper portion of the building. This result suggests that this design strategy created negative value differentiation amongst their rectilinear building peers in New York City. As a speculation, this may be due to the fact that 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.

Incorporating alternative technologies and approaches are needed to identify potentially omitted attributes or quantifying other building design metrics, such as algorithmic measurement of 3D complexity (Little et al., 1997; Gero & Kazakov, 2003), and computer vision technology for recognizing the presence of greenery or identifying building materials. Omitting architectural formal features from asset valuation may leave a missed opportunity to understand product differentiation and impact on the property market value caused by actual building design features during individual real estate property transactions. This then poses the same problem to both sides, a diminished design agency for both financial and design stakeholders during design, development and 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 (Chen & Owen, 1997). Enhanced methods may also potentially address the difficulty of interpreting the current research results by isolating individual design attributes or removing confounding factors.

Research on the value of design is moving beyond measuring design through assessing involvement of award-winning architects and moving into the study of physical design features. This distinction is important as not all architects come to be prize winning nor do all developers employ award winning designers. In this way, we may be able to understand the design decisions that create value and align the wider design community with valuation precedents. Our contribution is to create a relational understanding between building geometry, geography and real estate valuation techniques. 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.

References

Ahlfeldt, G., & Mastro, A. (2012). Valuing iconic design: Frank lloyd wright architecture in oak park, illinois. *Housing studies*, *27*, 1079–1099.

Allen, G. (1877). *Physiological aesthetics*. 5060. New York: D. Appleton.

American Planning Association (2014). Broadway: New york, new york. URL: `https://www.planning.org/greatplaces/streets/2014/broadway.htm`.

Asabere, P. K., Hachey, G., & Grubaugh, S. (1989). Architecture, historic zoning, and the value of homes. *The Journal of Real Estate Finance and Economics*, *2*, 181–195.

Bille, M., & Sorensen, T. F. (2016). *Elements of architecture: assembling archaeology, atmosphere and the performance of building spaces*. New York, NY: Routledge.

Brook McIlroy (2017). City of burlington tall building guidelines.

Buitelaar, E., & Schilder, F. (2017). The economics of style: measuring the price effect of neo-traditional architecture in housing. *Real Estate Economics*, *45*, 7–27.

Chan, C.-S. (2000). Can style be measured? *Design studies*, *21*, 277–291.

Chegut, A. M., Eichholtz, P. M., & Rodrigues, P. (2013). The london commercial property price index. *The Journal of Real Estate Finance and Economics*, *47*, 588–616.

Chen, K., & Owen, C. L. (1997). Form language and style description. *Design studies*, *18*, 249–274.

Cheshire, P., & Dericks, G. (2014). 'iconic design'as deadweight loss: rent acquisition by design in the constrained london office market, .

Ching, F. D. (1979). *Architecture: Form, space, and order*. Hoboken, NJ: John Wiley & Sons.

Ching, F. D. (1995). *A visual dictionary of architecture*. New York, NY: John Wiley & Sons.

Commission on Building Districts and Restrictions (1916). *Final Report : June 2, 1916*. New York, NY: City of New York, Board of Estimate and Apportionment.

Crilly, N., Good, D., Matravers, D., & Clarkson, P. J. (2008). Design as communication: exploring the validity and utility of relating intention to interpretation. *Design Studies*, *29*, 425–457.

Davis, B. (2010). Faslanyc. URL: `http://faslanyc.blogspot.com/2010/06/on-broadway-tactical-urbanism.html`.

Devlin, K., & Nasar, J. L. (1989). The beauty and the beast: Some preliminary comparisons of 'high'versus 'popular'residential architecture and public versus architect judgments of same. *Journal of Environmental Psychology*, *9*, 333–344.

Ferriss, H. (1929). *The metropolis of tomorrow*. Mineola, NY: Dover Publication.

Fuerst, F., McAllister, P., & Murray, C. (2009). Designer buildings: an evaluation of the price impacts of signature architects, .

Gero, J., & Kazakov, V. (2003). On measuring the visual complexity of 3d solid objects. *e-Activities in Design and Design Education, Europia, Paris*, (pp. 147–156).

Gifford, R., Hine, D. W., Muller-Clemm, W., Reynolds JR, D. J., & Shaw, K. T. (2000). Decoding modern architecture: A lens model approach for understanding the aesthetic differences of architects and laypersons. *Environment and Behavior*, *32*, 163–187.

Goldberger, P. (2001). URL: `https://www.paulgoldberger.com/lectures/new-york-and-the-new-urbanism/`.

Gómez-Puerto, G., Munar, E., & Nadal, M. (2016). Preference for curvature: A historical and conceptual framework. *Frontiers in human neuroscience*, *9*, 712.

Grant, J. (2001). The dark side of the grid: power and urban design. *Planning Perspectives*, *16*, 219–241.

Haskell, D. (). Building or sculpture? the architecture of'mass.'. *Architectural Record*, *67*, 366–367.

Hogarth, W. (1753). *The analysis of beauty: Written with a view of fixing the fluctuating ideas of taste*. Georg Olms Verlag.

Hopkins, J. R., Kagan, J., Brachfeld, S., Hans, S., & Linn, S. (1976). Infant responsivity to curvature. *Child Development*, (pp. 1166–1171).

Hough, D. E., & Kratz, C. G. (1983). Can "good" architecture meet the market test? *Journal of Urban Economics*, *14*, 40–54.

Kahn, E. J. (1926). Our skyscrapers take simple forms. *New York Times*, *4*, 22.

Kang, M. (2019). Dancing with the stars: The value of design in real estate development.

Koolhaas, R., Westcott, J., & Petermann, S. (2014). *Elements of architecture*. Venice, Italy: Marsilio.

Leder, H., & Carbon, C.-C. (2005). Dimensions in appreciation of car interior design. *Applied Cognitive Psychology: The Official Journal of the Society for Applied Research in Memory and Cognition*, *19*, 603–618.

Lindenthal, T. (2017). Beauty in the eye of the home-owner: Aesthetic zoning and residential property values. *Real Estate Economics*, .

Little, G., Tuttle, B., Clark, D. E., & Corney, J. R. (1997). Measuring geometric complexity of 3d models for feature recognition. *International Journal of Shape Modeling*, *3*, 141–154.

Madani Nejad, K. (2007). *Curvilinearity in Architecture: Emotional Effect of Curvilinear Forms in Interior Design*. Ph.D. thesis Texas A&M University.

Millhouse, J. A. (2005). *Assessing the effect of architectural design on real estate values: A qualitative approach*. Ph.D. thesis Massachusetts Institute of Technology.

Murphy & Kovach, J. (1972). Historical introduction to modern psychology.

Nase, I., Berry, J., & Adair, A. (2016). Impact of quality-led design on real estate value: a spatiotemporal analysis of city centre apartments. *Journal of ProPerty research*, *33*, 309–331.

Okamoto, R. Y., & Williams, F. E. (1969). *Urban Design Manhattan*. Cambridge, MA: MIT Press.

Pearson, D. (2001). *New Organic Architecture: the Breaking Wave*. Dubai, UAE: University of California Press with Gaia Books.

Plaut, S., Uzulena, E. et al. (2005). Architectural design and the value of housing in riga, latvia. *International Real Estate Review*, *9*, 112–131.

Rahadi, R. A., Wiryono, S. K., Koesrindartoto, D. P., & Syamwil, I. B. (2013). Attributes influencing housing product value and price in jakarta metropolitan region. *Procedia-Social and Behavioral Sciences*, *101*, 368–378.

Ranscombe, C., Hicks, B., Mullineux, G., & Singh, B. (2012). Visually decomposing vehicle images: Exploring the influence of different aesthetic features on consumer perception of brand. *Design Studies*, *33*, 319–341.

Roelfsema, P. R., Scholte, H. S., & Spekreijse, H. (1999). Temporal constraints on the grouping of contour segments into spatially extended objects. *Vision Research*, *39*, 1509–1529.

Rosen, S. (1974). Hedonic prices and implicit markets: product differentiation in pure competition. *Journal of political economy*, *82*, 34–55.

Salingaros, N. A. (1998). A scientific basis for creating architectural forms. *Journal of Architectural and Planning Research*, (pp. 283–293).

Santayana, G. (1896). *Sonnets and Other Verses*. Stone and Kimball.

Shepley, M. M. (1982). Age changes in spatial and object orientation as measured by architectural preference and eft visual performance, .

Spencer, H. (1873). Psychology of the sexes. *Popular Science Monthly*, *4*, 30–38.

Valentine, C. W. (1913). The aesthetic appreciation of musical intervals among school children and adults. *British Journal of Psychology*, *6*, 190.

Vandell, K. D., & Lane, J. S. (1989). The economics of architecture and urban design: some preliminary findings. *Real Estate Economics*, *17*, 235–260.

Vartanian, O., Navarrete, G., Chatterjee, A., Fich, L. B., Leder, H., Modroño, C., Nadal, M., Rostrup, N., & Skov, M. (2013). Impact of contour on aesthetic judgments and approach-avoidance decisions in architecture. *Proceedings of the National Academy of Sciences*, *110*, 10446–10453.

Westerman, S. J., Gardner, P. H., Sutherland, E. J., White, T., Jordan, K., Watts, D., & Wells, S. (2012). Product design: Preference for rounded versus angular design elements. *Psychology & Marketing*, *29*, 595–605.

Willis, C. (1986). Zoning and" zeitgeist": The skyscraper city in the 1920s. *Journal of the Society of Architectural Historians*, *45*, 47–59.

Willis, C. (1995). *Form Follows Finance: skyscrapers and skylines in New York and Chicago*. New York, NY: Princeton Architectural Press.

Appendix

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.

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.

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.

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.

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.

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