Value in Design? Features, Pricing, and Design Strategies

By

Shane Xue Ying Zhang

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Signature of Author: ______________________________

Department of Architecture
Center for Real Estate
January 16, 2020

Certified by: ______________________________

Takehiko Nagakura
Associate Professor of Design and Computation, Department of Architecture
Thesis Supervisor

Certified by: ______________________________

Andrea Chegut
Research Scientist, Center for Real Estate
Thesis Supervisor

Accepted by:
____

Leslie K. Norford
Chairman, Committee on Graduate Students, Department of Architecture

Accepted by:
____

Dennis Frenchman
Class of 1922 Professor of Urban Design and Planning
Director, Center for Real Estate
Department of Urban Studies and Planning and Center for Real Estate

Thesis Committee

Takehiko Nagakura
Associate Professor of Design and Computation
Department of Architecture
Thesis Supervisor

Andrea Chegut
Research Scientist
Center for Real Estate
Thesis Supervisor

Dennis Frenchman
Class of 1922 Professor of Urban Design and Planning
Thesis Reader

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ABSTRACT

Where is the value of design? Clients who are using buildings to solve societal economic needs rely heavily on real estate asset valuation models to guide their decision-making process; however, these asset valuation models often oversimplify the asset and only attempts to capture the crudest elements of the building (in most cases, only the square footage of the building is represented). Such crude abstraction of the asset results in the client's over-emphasis on elements that are represented within the valuation model as key value drivers for a project (e.g. the square footage). As a result, architects are often confronted with the challenge of mediating between their design interventions and the client's value-driven design approach. The result of this misalignment of design approaches are suboptimal design and economic outcomes. As an attempt to address this misalignment, I've investigated twenty internal and external architectural features such as external materiality, internal materiality, column spacing, and the number of building entrances to see whether there are architectural design features that are statically and economically significant in contributing to the value of the building. The intention is to identify elements where consistent financial value can be documented within design practice. There is limited data on design features so I chose to focus on the New York City commercial office market. While this represents a small subset of the entire real estate market, it has allowed the research to derive some key insights from an otherwise extremely opaque market. I documented and investigated twenty design features. Twelve of these architectural features were found to be statistically and economically significant in contributing to pricing differentials relative to their building peers. These results suggest that there is a significant impact of interior and exterior architectural design interventions that help to create relative value differential for commercial office buildings.

Thesis Co-Supervisor: Takehiko Nagakura
Title: Associate Professor of Design and Computation, Department of Architecture

Thesis Co-Supervisor: Dr. Andrea Chegut
Title: Research Scientist, Center for Real Estate

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Shane Xue Ying Zhang
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Master of Science in Real Estate Development
Massachusetts Institute of Technology
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1. Introduction

In 2014, Frank Gehry was famously quoted saying that 98 percent of what gets built today lacked design (Winston, 2015). While such representation of the overall proportions may be an exaggeration, it does represent the underlying reality in the current built environment, where many built projects are simple rectangle boxes with minimal design features. What is driving this simple-box building reality and why aren't there more buildings with more design features? To answer this question, one would have to first understand the process of how a building is realized, sustained, and traded in the real estate market.

The most common way for a building to be realized is through a for-profit real estate developer. The developer is responsible for identifying the opportunity, organizing the necessary human capital and funding, and executing the implementation strategy to bring a project to life. Naturally, the goal of the for-profit developer is to deliver a profit for his investors; however, because investors often require the project to deliver a profit that's higher than a certain target (usually a return of more than 15% per year to justify the development risk), the developer is obligated to make decisions that enable him to deliver that return. As a result, the developer must optimize his decision-making process in hitting that return hurdle for its investors.

Once a building is executed and realized, it will often be sold or leased. In most cases, tenants will then be moved into the building and the building will start to generate a steady stream of cash flow from the rent payments. When a building is bought or sold on the real estate market, the value of the building is often determined by the existing and future potential cash flow of the building.

The method in which the developer decides whether a project is feasible to achieve the necessary return for his or her investors is often through a Pro-forma. The goal of the Pro-forma is to allow the developer to determine whether the residual profits - by subtracting the cost from the total value that is generated by the project – is enough to satisfy the required rate of return by the investors. After a series of rigorous analyses, if the project is deemed feasible (i.e. the residual profit can satisfy the required rate of return), then the developer will initiate the project; else, the project will not be pursued. Figure 1 depicts a sample proforma that is often used by developers and investors to evaluate a project.

The way that the future value of the project is determined is through real estate asset pricing cash flow forecasts. In most cases, the value of the project is heavily anchored to the amount of square footage there is in the project multiplied by the expected value per square feet at the time of completion. What this means is that most of the time the only feature that is descriptive of the building itself is the square footage, ignoring all other elements that contribute to the expected value per square feet at the time of completion. In some instances, the program of the building is also considered, which may have elements of design included, but this is not always the case.

Over the last 50 years, the asset pricing forecasts for real estate has been gradually improving to consider various other drivers of real estate value. More recently, the hedonic pricing method or the repeat sales approach (or some hybrid of the two) are used to understand the way neighborhood and building features impact the building value (Chegut et al., 2013). Simply, the pricing model aims to measure the drivers of utility that users are willing to pay for and have shown to pay for through the analysis of historical data, and as a statistical tool, it intends to explain the drivers of a building's price, rent, cost, that create differentiated value from one's peers (Chegut et al., 2019).

To perform the valuation of a building using these asset pricing models, valuation modelers consider the following as core features for driving asset value: building size, age, number of stories, the status of renovation, location, and proximity to Central Business District (Chegut et al., 2019). Such quantified approach is a key driving force behind the decision-making processes investors, developers, and financiers may take on hand. On the other hand, architects consider much more qualitative elements of architecture during the design process, such as materiality, geometry, daylight, views, and spatial transformability to cater to both functional and aesthetic needs (Chegut et al., 2019). These features that are designed by architects help to differentiate and improve the performance of the underlying building; however, when designing these features, their emphasis has often been on the cost of the feature rather than the net value that the feature is delivering to the project. Although intuitively, these features are what helps to drive value for the project, the value add of these features has mostly stayed within the qualitative realm, therefore it is difficult for the architect to justify them quantitatively to the financially driven decision-making process of the investors, developers, and financiers. Hence, projects are often stripped down to its bare minimum in its design features during the value-engineering phase to reduce cost and increase the baseline profitability of the project. Namely, these features are not systematically measured and therefore do not get in turn get counted.

Architectural design features are also often overlooked by the current practices of evaluating the value of commercial real estate, either by the lack of means of collecting relevant data regarding building features or the lack of interest of the valuation stakeholders to engage with the language of design. The result is that these models often oversimplify the asset and only attempt to capture the crudest elements of the building. Such crude abstraction of the asset results in the client's over-emphasis on elements that are represented within the valuation model as key value drivers for a project (e.g. the square footage) and drastically de-emphasize any other building features that are deemed to non-value generating. One can see that in the sample proforma, the only feature that is included in the pricing is the square footage of the building. Even though the implementation of some of these features may result in net value add for the project in a qualitative sense, such effect has not yet been thoroughly quantified and therefore cannot be justified within the real estate pricing model. As discussed earlier, since the real estate pricing model drives the decision-making process for the investors, developers, and financiers of the project, what is not included in the pricing model will often not be deemed as vital to the success of the project. Hence, architectural design features are often seen as an amenity.

However, ignoring these features from asset valuation models represents a missed opportunity to understand how architectural design features influence a property's market value and suggests an overlooked economic opportunity to understand the drivers for product differentiation in the competitive real estate market. Furthermore, because most of the values that are currently associated with architectural design features are only understood in their qualitative terms, it deprives the ability for architects to quantitively back their design decisions, thus marginalizing the value of architectural design features and leading to the plethora of minimum viable buildings with few design features. This study will attempt to start quantifying the value of some of these architectural design features to help equip architects with the necessary tools for to back their design decisions, to help financial stakeholders to unlock more value for their projects, and to increase the synergy between a project's architects and its financial stakeholders. **To understand this alignment, I asked the following questions:**

1. What architectural design elements of an office building have been observed to contribute positively to the building's transaction value?
2. What architectural design elements of an office building have been observed to contribute negatively to the building's transaction value?

3. What would a building designed only with features aimed for economic value creation look like?
4. Finally, ignoring what has been depicted in the data already, how can I use my designs to inform what data we need to collect for my commercial office speculative design.

Architectural design features are often viewed as an amenity and therefore are supplementary to the viability of the project; However, based on the findings of this paper as well as many other related literatures in the field, there are strong evidence suggesting that architectural design features of a building are in fact key contributors to the realizable value of the project. The intent of this research is to provide a bridge between the design knowledge of architects and the financial impacts of these design decisions. The idea is to not to limit future developments to a few set solutions, but rather it is about bridging the gap between design and finance and opening more possibilities on design strategies that are proven to contribute value, so that both architects and developers could better calibrate their projects to the needs of the users, investors, and other stakeholders of the project.

2. Relevant Financial Concepts to Consider

To understand the link between design and value there are relevant financial concepts to consider and discuss relevant to understanding design not just as an amenity, but as something necessary for value. Humans who occupy space require thoughtful interventions that create satisfaction and thereby are demanded for their use. How can this be understood in the context of economic thought and utilized in this framework.

Utility Maximization

To understand the relevance of finding design features that generates financial value for the owner, it is important to consider the concept of utility in a capitalistic context. The way a need or a desire is expressed in the capitalistic market is through the opportunity for one to profit. Goods are valued for their utility-bearing attributes or characteristics (Rosen, 1974); therefore, if one type of good is priced higher than others, such premium reflects a higher utility that can be gained by the consumer of that good (Rosen, 1974). Through this lens, one can start to understand the immense benefit of finding design features that help to drive pricing. Since a building's pricing reflects the utility that can be derived by the user of that space, the higher the price for a space means more value or utility that is gained by the user that is consuming the space. Granted, the pricing of an office space can also be greatly influenced by real estate cycles and other macro level events; however, if one controls for such external factors (e.g. through the hedonic pricing method that is implemented in this study), then one could start to isolate the effect of these design features and understand its influence on the building's pricing.

Discounted Cash Flow

Discounted Cash Flow (DCF) is probably the single most important quantification procedure in micro-level real estate investment analysis. (Geltner et al., 2014) The procedure consists of three steps:

1. Forecast the expected future cash flows.
2. Ascertain the require total return.
3. Discount the cash flows to present value at the require rate of return.

In an essence, for a real estate project to be feasible, the cash flow that it generates needs to satisfy the return required by the investor for risks that they are taking. The longer the project takes, the higher total return that is required to be produced by the project. For office buildings, such cash flow comes in the form of rental income by leasing office spaces to tenants. The better the office space meets the needs of its tenants the higher potential rental income can be generated relative to its building peers. When the building is bought or sold on the real estate market, the higher cash flow will be translated into a higher transaction price relative to its peer groups; such transaction data is used to help to derive insights of this study. It is important to note that how a building is designed and the type of architectural features it contains directly impacts how well the space meets the needs of its tenants, and therefore it is important to not only consider the location and the amount of available space within the building, but to also consider the quality of the spaces that are being offered to its tenants as a key contributor to the building's overall value.

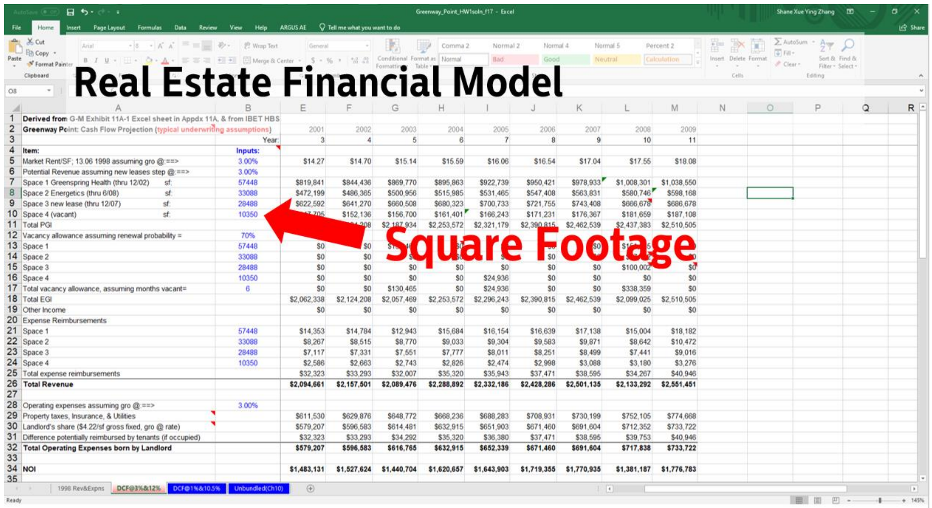


Figure 1. Sample Real Estate Pro-forma.

Net Present Value (NPV) & Internal Rate of Return (IRR)

The NPV of an investment project or a deal is defined as the present dollar value of what is being obtained minus the present dollar value of the cost (Geltner et al., 2014). The present dollar value is the future dollar value discounted at a discount rate that is appropriate for the investment's risk level. The IRR of a project is the discount rate of the project when NPV equals to 0. The concept of Net Present Value and Internal Rate of Return is relevant because real estate investors and developers use both metrics as a way to gauge the feasibility and the attractiveness of a project. A developer in theory should never accept a project where the project NPV is less than zero. Additionally, when a project is initiated, a certain project level IRR is forecasted, and it is up to the developer to achieve the forecasted rate of return; thus, any actions or events that subtracts from the forecasted rate of return is highly undesired. On the other hand, any actions or events that adds to the forecasted IRR and NPV is highly desired. Mismeasurement is common here as design features are not forecasted in a positive or negative direction either way.

3. Literature Review

The existing literature regarding the value of architectural design can be broadly broken down in to two main categories: buildings designed by awarded designers or have received awards (Millhouse, 2005; Fuerst et al., 2009; Kang 2019) and the economic value of architectural design features (Hough and Kratz, 1983; Chegut et al., 2019; Turan et al., 2019).

In the first category of research, Fuerst, McAllister, and Murray (2009) investigated whether commercial office buildings designed by starchitects in the United States were able to achieve rental premiums when compared to commercial office buildings that were designed by non-starchitects. They focused on buildings that were designed by Pritzker Prize and the Gold Medal winners and have found that office buildings designed by these award-winning architects were able to achieve a rental premium of approximately 5%. Similarly, Kang (2019) found that in New York City, buildings that were designed by award winning architectural firms were able to achieve 23% premium in its transacted price when compared to nearby buildings that were designed by non-award-winning architectural firms. While this category of research was able to demonstrate that there is a strong correlation between the brand of the architect and the premium on the building's transaction price, such observation does not explain the whether there building feature differentials may have contributed to the premium as it simply relates the observed premium to the reputation of the architect.

This research will be focused on the second category – the value of architectural design features. In the paper "Can 'Good' Architecture Meet the Market Test", Hough and Kratz (1983) investigated whether the architectural quality of a building had economic impacts on its commercial value. For their research, Hough and Kratz used Chicago's office market as a testing ground and implemented the hedonic pricing model to test whether the quantifiable characteristics of an office building, such as age, height, location, amenities, landmark status, and award-winning status of the building, had impacts on its commercial value. Although the study attempted to capture the quality the architectural design through the landmark and the award-winning variable, the study did not explain the value of specific architectural features that might lead to added value for the project.

With the research on the value of daylight in office spaces, Turan, Chegut, Fink, and Reinhart (2019) found that there were 5 to 6 percent rent premium for office space with high levels of daylight when compared to spaces with low levels of daylight. Such observation makes logical sense as it is clear that tenants would prefer spaces with better daylights than dark office spaces; however, it is not till the research performed by Turan et al. that we were able to place a quantifiable value on the price of good daylight. In the research regarding the value of design in real estate asset pricing, Chegut et al. (2019) found that properties with diagonal intersections, building curvature, and podium extrusions have positive pricing differential relative to their building peers of 6.8 percent, 13.1 percent, and 10.0 percent more, respectively. Zoning setbacks have negative pricing differential relative to their building peers of 14.6 percent. Such results suggest that there is a significant impact of architectural design features that aesthetically and functionally differentiate the building and is being reflected in the building's transacted price in the real estate market. This research will build on the existing literature on the value of architectural design features and will aim to identify and quantify more architectural design features for its relative value contribution to the property's transaction price.

4. Data and Methodology

In this study, I employed the hedonic pricing model to analyze and understand commercial real estate pricing dynamics. The idea is to build on top of the existing dataset from MIT Real Estate Innovation Lab (REIL) with the dataset sourced from Beacon so that I will be able to make observations while controlling for existing features such as the property's location, transaction period, and its exterior geometries.

4.1 Data Sources

Real estate has traditionally been a field that is opaque and is slow to respond to technological changes, it is not until very recently the trend of mass adaptation of data has caught up with this field. The most well-known data platforms for such movement are Real Estate Capital Analytics (RCA) and CompStak; however, because the industry is still at its very early stages, and because the data are often aggregated from public sources, the quality of the data is still very rough. In fact, most of the building features within the dataset are still very abstract and are mostly concerned with its size and age (e.g. square footage, number of floors, building age). While these features/metrics can be complementary to this thesis, the core of this investigation will be focused on evaluating specific commercial building features and therefore more fine-grained data regarding buildings' exteriority and interiority will be needed.

While these types of fine-grained data are unavailable to the public, I was extremely fortunate to be provided access to an internal database by Beacon Capital Partners, LLC ("Beacon") through the generosity of its senior management. Since Beacon has been in the real estate industry for over 70 years, it has built up an internal database of transacted commercial office buildings, with much more fine-grained data regarding the features of the building. I am extremely grateful for Beacon's generosity and the support of MIT Real Estate Innovation Lab. It is only through the combination of Beacon's internal database and MIT Real Estate Innovation Lab's dataset derived from CompStak and RCA that I was able to deliver the insights of this thesis.

After combing data from the different sources, I was able to construct a dataset with 39 variables and 127 observations for commercial office real estate in Manhattan over the 2001 and 2018 period. As discussed, the difficulty has been about sourcing quality data to increase the number of observations such that the results could be more robust; however, while the number of observations is quite small, the quality of the combined dataset is sufficient in providing the study with insights into how the suggested architectural design features influence the observed transaction prices.

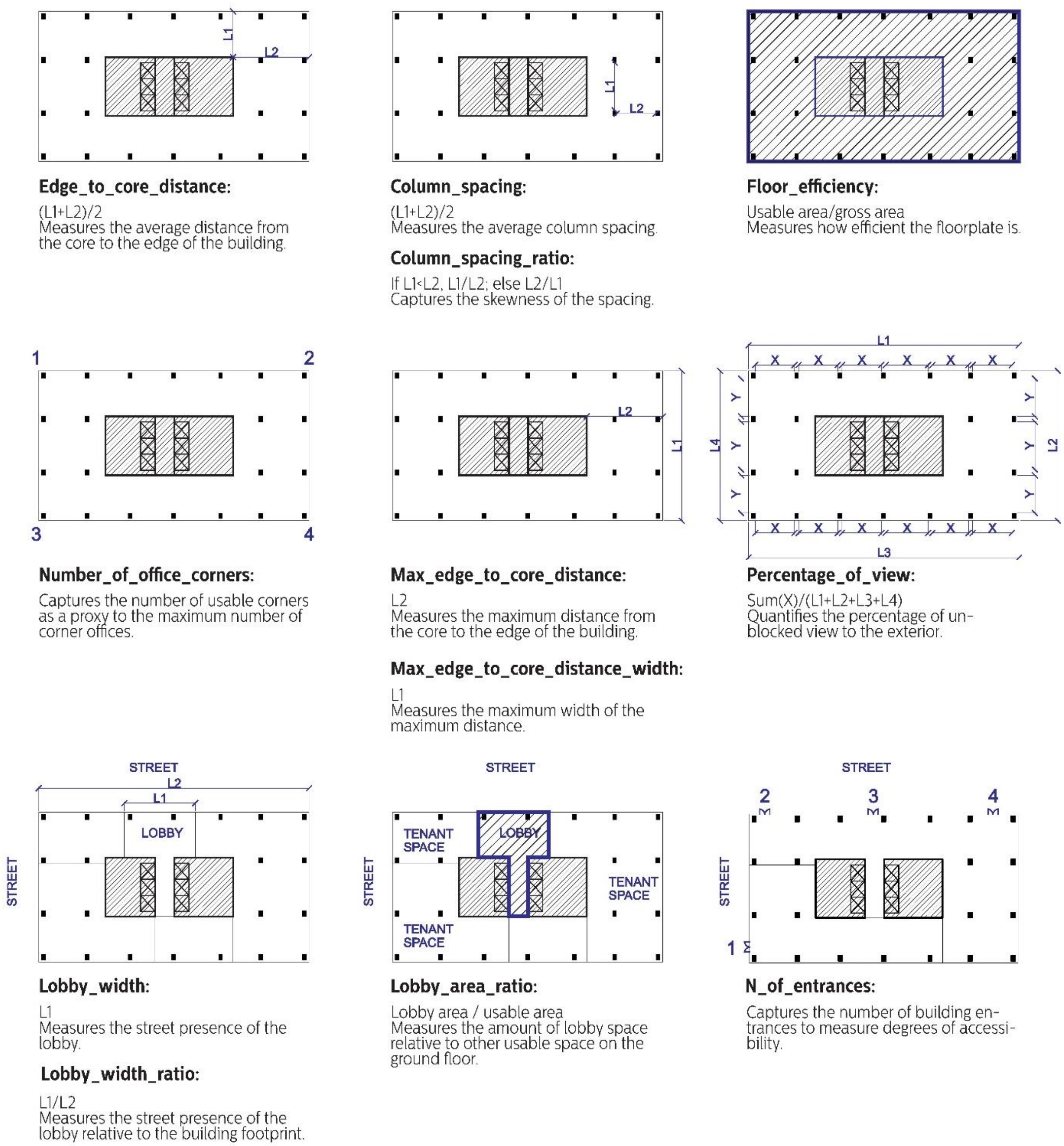
4.2 Features of Design

Below are existing data features sourced from MIT REIL, CompStak, and Real Capital Analytics. Since there are many factors (such as the location, transacted date, building class, etc.) affecting the actual transacted price of the property, one must control for their contribution in order to isolate the effect of the finer-grain design feature that one is attempting to examine. To achieve this, features from the existing data set were included so that we could control for location and transaction time, simple building features, transaction features, and external building geometries. Table 1 represents the features that were included in the overall dataset to achieve this result.

In addition to existing data features, 20 new features were sourced and added from Beacon's internal dataset to explain finer-grained feature-driven value differential for New York City commercial office buildings. The focus was to derive quantifiable office features that can be objectively measured and are representative of the building design while minimizing biases and creating a set of features that can be repeatedly applied to different properties. See figure 2 for the list of new features. The goal of this list is not to serve as an exhaustive list of features, but rather as an initial step of an attempt to quantify the features that goes into designing an office building.

Table 1: Controlling Features

Features	**Description**
RCA Submarket	Location of the property
Land Area (acres)	Area of the existing land
Number of Buildings	Number of buildings for the transacted property
Number of Floors	Average number of floors per building
Core/Value-Add	Checks whether the property is a core or a value-add
Building Age	Age of the property
Walk Score	Walk Score, measures the walkability of the property
Transit Score	Transit Score, measures how well a location is served by public transit
Building Class	The building class of the property – A,B, or C
Reno Dummy	Checks whether the building has been renovated
Log(SqFt)	Log transformed the total square feet of the property
Euro/USD	Euro/USD foreign exchange rate
Jpy/USD	JPY/USD foreign exchange rate
Transaction Year	Transaction year
Curvy Dummy	Assesses whether the property has noticeable curvy features
Zoning Dummy	Assesses whether the property has a unique form due to New York's zoning setback regulation
Podium Dummy	Assesses whether the property has a podium that is between one and ten story tall
Diagonal Dummy	Assesses whether the property has an irregular form due to the spatial structure of the existing road network



Mix_use: checks whether the building has any other programmatic use.

Material_lobby: captures the dominate materiality of the lobby.

Material_exeterior: captures the dominate materiality of the building's exterior.

Public_space: checks whether the building provides any public space.

Slab_to_slab_height: measures the average slab-to-slab height of the office space.

Column_free checks whether the building is column free.

Terrace_access: checks whether the building have terraces that occupants can access.

Lobby_height: measures the average clearance of the lobby.

Figure 2: Design Features

4.3 Statistical Approach to Feature Valuation

The hedonic pricing method was employed in this study to understand and analyze commercial office real estate pricing differentials. The hedonic pricing method captures the impact of the features and characteristics of a property on its asset pricing (Rosen, 1974). I employed a semi-log model to estimate the statistical and economic impact of twenty architectural features that are being measured in the building. The model is specified as follows:

$$logP_i = \alpha + \beta X_i + \gamma g_i + \varepsilon_i, \qquad \text{(eq. 1)}$$

where P represents the observed transaction price per square foot in commercial office real estate transaction i. X is a vector containing hedonic characteristics of building's transacted in i, and g is a vector of architectural feature variables that represent a 1 should the traded building have this feature and 0 otherwise. α represents an estimated constant, β and γ are estimated coefficients, and ε is an i.i.d. error term.

4.4 Future Design Features

Based on the findings, I made some recommendations on design strategies that architects and developers could implement in their future projects. Through visual examples, I display how such implementation could shape the project. These visual examples were located on a hypothetical site in New York City's Financial District. The site was chosen because of its appeal as an office location due to its proximity to public transportation, its walkability, its proximity to other firms, its exposure to multiple street frontage, and the ability to fit large floor plates that are desirable to the modern office tenant.

To enable a more robust evaluation and implementation of architectural design features that contributes to the value-differential of office buildings, more design features should be added to the evaluation dataset. While the current state of the available real estate data does not provide insights into many of the features that are being recommended below, the hope is that soon such wide-data collection would be feasible. The recommended additional design features to be collected are: the type of building structure system, whether the building have green spaces, the type of façade system, amount of fresh air within the building, the spatial variation of the building, and the mix of amenity programs within the building. To collect such data, one could look at existing documentations of building system and breakdowns and deploy manual labor to scrap such data. One could also deploy an algorithm to scrap the data if the accuracy is high enough to implement such data collection at scale. However, such approach assumes that one could gain access to building documentations, which are often confidential and therefore represents a hurdle that one would have to overcome.

5. Results

After analyzing the data with the hedonic pricing method, results were broken down into three categories: Office Interior Features, Ground Floor Features, and Materiality Choices. Office Interior Features focused on interior architectural elements that makes up an office space, such as column spacing, amount of exterior view, and the number of office corners. Ground Floor Features focused on architectural features that makes up the ground floor space and captures whether the property has mixed programming on the ground floor. Materiality Choices are features that are directly related to the materiality of the lobby and the building's exterior envelope.

Office Interior Features

Table 2 documents the impact of interior features on the value of the overall office property. Looking at the results, we see that the signs of the coefficient are correct and logical. For example, having column free spaces, more office corners, and higher slab-to-slab height have been observed to contribute positively to the value of the office space. However, it appears that out of the eleven interior features, only five of them have statically significant coefficients. The five interior features are: column free, number of office corners, edge to core distance, maximum edge to core distance, and maximum edge to core distance (width). Out of the five features, only edge to core distance was observed to contribute negatively to the property value. Such observation makes intuitive sense as one does not want overly deep lease spans as it drastically reduces the quality of light within the space.

Table 2: Architectural Design Features – Office Interior
Dependent Variable: Logarithm of Transaction Price per Square Feet

Dependent Variable:	Log(Price per Sq Ft)	
Column free	2.790	*

	(1.201)	
Number of office corners	0.157	*
	(0.071)	
Edge to core distance	-0.019	*
	(0.008)	
Max edge to core distance	0.012	*
	(0.005)	
Max edge to core distance width	0.009	***
	(0.002)	
Slab to slab height	0.077	
	(0.113)	
Floor efficiency	0.058	
	(4.210)	
Percentage of view	0.018	
	(0.907)	
Terrace access	-0.060	
	(0.164)	
Column spacing	-0.009	
	(0.013)	
Column spacing ratio	0.001	
	(0.498)	
Constant	-73.570	**
	(25.280)	
Observations	127	
R-squared	0.886	
Location & Transaction Time FE	YES	
Simple Building Features FE	YES	
Transaction Features FE	YES	
External Building Geometries FE	YES	
Adj R-squared	0.795	

*** = statistically highly significant (p value < 0)

** = statically very significant (p value < 0.001)

* = statistically significant (p value < 0.01)

Ground Floor Features

Table 3 documents the impact of ground floor features on the value of the overall office property. Looking at the results, we see that the signs of the coefficient are logical and intuitive. For example, having public spaces, mixed use programing, and good lobby presence relative to the street (lobby width ratio) have been observed to contribute positively to the value of the office property. Out of the seven interior features, six of them have statically significant coefficients. The six ground floor features are: public space, lobby width, lobby width ratio, lobby area ratio, number of entrances, mixed use programming, and lobby height. Out of the six features, public space, mixed use programming, and lobby width ratio contributes positively to the property transaction value where as lobby width, lobby area ratio, and number of entrances contributes negatively to the property transaction value.

Materiality Choices

Table 4 documents the impact of materiality choices on the value of the overall office property. Looking at the impact of materiality choices, we can observe that out of the five materiality features, four of them have statically significant coefficients. The four features are focused on the dominate materiality in lobby space and are all relative to the brick material. As expected, using LEDs, marbles, masonry, or wood are all significantly better value contributor than brick. Based on the results, it is interesting to note that using LED displays in the lobby space significantly outperforms any other material choices.

Table 3: Architectural Design Features – Ground Floor

Dependent Variable: Logarithm of Transaction Price per Square Feet

Dependent Variable:	Log(Price per Sq Ft)	
Public space	1.088	**
	(0.401)	
Lobby width	-0.021	**
	(0.007)	
Lobby width ratio	0.039	**
	(1.271)	
Lobby area ratio	-0.018	*
	(0.765)	
Number of entrances	-0.083	*
	(0.032)	
Mixed use	0.370	*
	(0.183)	
Lobby height	-0.014	
	(0.026)	
Constant	-73.570	**
	(25.280)	
Observations	127	
R-squared	0.886	
Location & Transaction Time FE	YES	
Simple Building Features FE	YES	
Transaction Features FE	YES	
External Building Geometries FE	YES	
Adj R-squared	0.795	

*** = statistically highly significant (p value < 0)

** = statically very significant (p value < 0.001)

* = statistically significant (p value < 0.01)

Table 4: Architectural Design Features – Ground Floor

Dependent Variable: Logarithm of Transaction Price per Square Feet

Dependent Variable:	Log(Price per Sq Ft)	
Material lobby-LED	2.352	***
	(0.543)	
Material lobby-Marble	1.290	***
	(0.412)	
Material lobby-Masonry	1.991	***
	(0.574)	
Material lobby-Wood	1.721	**
	(0.646)	
Material exterior-Masonry	-0.034	
	(0.278)	
Constant	-73.570	**
	(25.280)	
Observations	127	
R-squared	0.886	
Location & Transaction Time FE	YES	
Simple Building Features FE	YES	
Transaction Features FE	YES	
External Building Geometries FE	YES	
Adj R-squared	0.795	

*** = statistically highly significant (p value < 0)

** = statically very significant (p value < 0.001)

* = statistically significant (p value < 0.01)

Summary

Based on the findings, one can observe that there are architectural design features that are statistically significant in contributing or subtracting from an office property's transaction value. As a direct reflection of the difficulty in sourcing quality fine-grain data in the field of real estate, the sample size that was used to derive the results was relatively small and therefore it would be prudent to one to interpret the results through its signs (positive or negative) and its relative magnitude rather than attempting to arrive at a specific numerical value of contribution. By grouping features based on how the feature is measured (i.e. as percentage terms, count, binary terms, or as continuous variable) one can get a sense of which features contribute more relative value to office properties.

From figure 3 we see that out of five features that were measured as a percentage, only two of them were statistically significant, with lobby width ratio being a positive value contributor and the lobby area ratio being a negative value contributor. What this is suggesting is that having a good street presence for the lobby is good for the value of the property; however, an overly large lobby as a percentage of the overall ground floor area is not desirable. Such observation makes intuitive sense as an overly large lobby often leads to excessive empty spaces and therefore more likely for the ground floor to lack vibrancy. Additionally, an excessively large percentage of lobby area means there is less space for other programs, such as pubic spaces and retail spaces, which subtracts from the overall vibrancy and the attractiveness to office tenants.

For features that were measured by integers (i.e. the count method), one can observe that both were statistically significant in their value contribution. From the data collected, one can observe that relative to their peers, buildings with more corners were observed to transact at a premium. Again, such observation makes intuitive sense as office corners are often a highly desirable interior feature. On the other hand, buildings with a large number of entrances were observed to transact at a discount relative to their peers. One likely explanation for this is that as the number of access points for the property increases, the owner would be forced to increase security measures for the property and therefore resulting in higher operating costs and a discount for the building's transaction price.

Out of the seven features that were measured as continuous variables, four of them were observed to show a statistically significant contribution to the overall value of the commercial office property. Out of the four that were statistically significant, max edge to core distance and max edge to core distance (width) were observed to have positive value contribution. In combination, these two features represent the maximum amount of uninterrupted open space on an average floorplate; therefore, the observation that an increase in the uninterrupted open space leads to a higher office value makes sense because the result is more flexibility in terms of how a tenant can organize the workspace. It is important to note that a similar feature that measures the average lease span (edge to core distance) was observed to contribute negatively to the office value. Such a result does not present a contradiction, but rather a confirmation as the minimum lease span within the dataset was 30 feet and therefore such observation is about a reflection that excessively deep lease spans decrease office space value. With excessively deep office space, it will result in poorer lighting conditions and therefore subtract from the desirability of the space as a workspace for office tenants. This finding is also consistent with the results that were found by Reinhart, Turan, Chegut, and Fink (2019), where they found that office buildings with better daylight conditions were traded at a 5 to 6 percent premium relative to buildings with poor daylight conditions. Lastly, buildings with excessive lobby width were observed to trade at a relative discount. This finding is consistent with earlier findings that suggested excessively large lobby commands a relative discount on the market place.

The remaining nine features were measured as dummy variables (binary, yes or no). Out of the nine features, seven of them were found to be statistically significant in their value contribution to office properties. Properties that had column-free interior spaces were observed to command a large positive premium relative to properties that had interior columns. Properties that had dedicated public spaces on-premise were also observed to command a sizable premium over properties that did not have any public spaces. Finally, properties that had mixed-use programming on the ground floor were also observed to trade at a premium relative to properties that were purely dedicated to office use. In terms of the materiality choices, the results show that relative to the use of brick as the main material in the lobby space, lobbies that were designed with LED displays commanded the highest premium, with lobbies that were designed with masonry commanding the second-highest premium, wood commanding a close third place in its relative value contribution and marble being ranked the fourth among the value contributors.

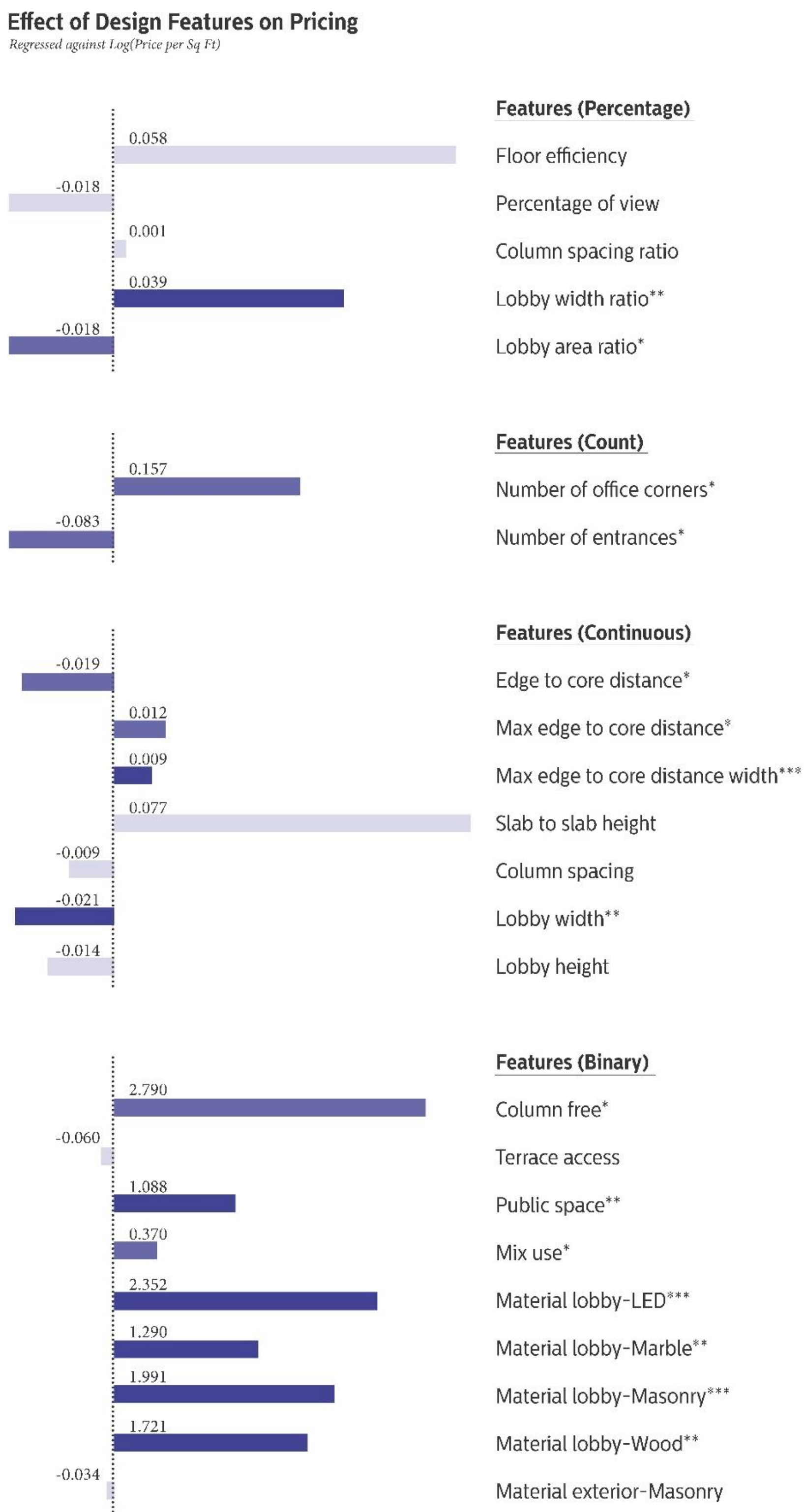


Figure 3: Summary of Results
Note: these coefficients represent the magnitude of its contribution to the observed transaction price. Since the coefficients are regressed against log (price per Sq Ft), the coefficients here represent an exponential magnitude of contribution.

6. Design Implementation Strategies

Currently, architectural design features are often seen as an amenity to the project instead of a necessity to the viability of the project. What this often leads to is excessive value-engineering and sub-optimal design processes. The problem is that there are misalignments between the toolkits of the developer and the architect and therefore it is important to create a relational understanding between how a building is designed and the valuation models that are used by the developer. This chapter aims to provide visual examples of how one could implement value-adding strategies on a hypothetical site.

If one combines the findings of this paper with results found by Chegut, Kang, Rong, and Yang (2019) where certain external building features were found to provide statically significant value differential, then one could start to formulate a set of design strategies that are beginning to contribute to the value creation (hence, the viability) of the project. For such project, design features will no longer be viewed as an amenity, but rather as the source of direct value creation. Since developers are obligated to maximize the value of the project, this will create a strong incentive for developers to implement more design features on the project whenever the cost of doing so can be justified by the additional value that is generated for the project. As project costs are often unpredictable due to the unpredictability of construction and capital costs, the following illustrations provided in this section will be performed under the assumption that the value created by the additional design features outweighs its cost and therefore the developer is incentivized for implementation. The goal of this section is to provide the reader with a visual illustration of how the findings of this research could be applied to future projects.

6.1 Site

To provide visual examples of how one may implement the findings in a project, a New York City site in the financial district was selected. The purpose of the site for this research isn't to construct a fully developed architectural project that has taken into all possible considerations; rather, it is to use the hypothetical site as a tool to visualize how a value-driven, feature oriented process could shape a real estate project that focuses on generating economic value for its stakeholders.

The hypothetical site was chosen to be an L shape to expose the project to corner conditions and multiple street frontage possibilities. The site was also measured to be large enough to meet the needs of a contemporary office tenant, with the potential for large floor plates that are ideal for the collaborative nature of the modern work environment. Finally, the site is within proximity to large transit nodes to further enhance its desirability as a commercial office site.

6.2 Implementation Example

From the research done by Chegut, Kang, Rong, and Yang (2019) we see that in New York City, office buildings with diagonal intersections, building curvature, and podium extrusions have positive pricing differential relative to their building peers of 6.8 percent, 13.1 percent, and 10.0 percent more, respectively. Zoning setbacks have a negative pricing differential relative to their building peers of 14.6 percent. If one implements such observation on a project located on the hypothetical New York City site (figure 4), one might arrive at designs that are variants to the ones shown in figure 5 to 7 as an attempt to harvest the price premium that were associated with curvature and podium designs.

Such design intervention takes the conventional developer approach of maximizing the building's square footage and adds a layer of intelligent architectural design element to help the owner differentiate the building from its competitors without compromising the quantity and the quality of rentable office space.

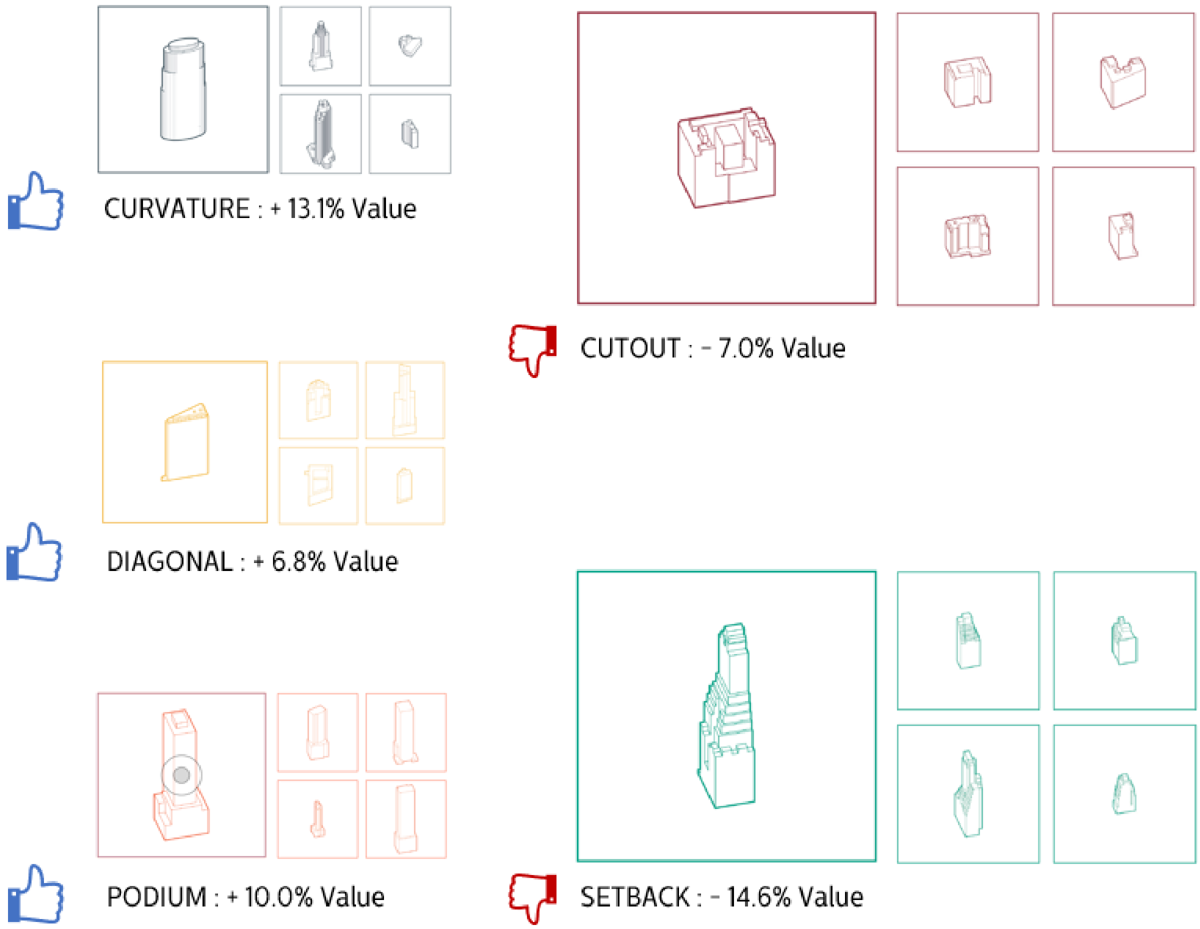


Figure 3: The Value of Design In Real Estate Asset Pricing (Chegut, Kang, Rong, and Yang, 2019)

Figure 4: Hypothetical Site

Location: New York City, Financial District
Lot Size: 33,500 SqFt
Zoned for Commercial or Manhattan Residential (v1)
FAR = 15.0

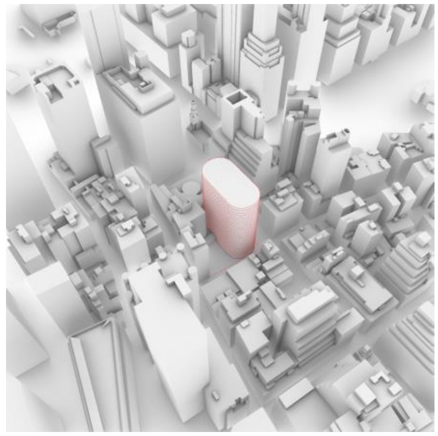


Figure 5: Curvy Building Iteration 1
This represents the implementation of the curvature feature that was observed to provide the office building with a relative premium on its transaction price.

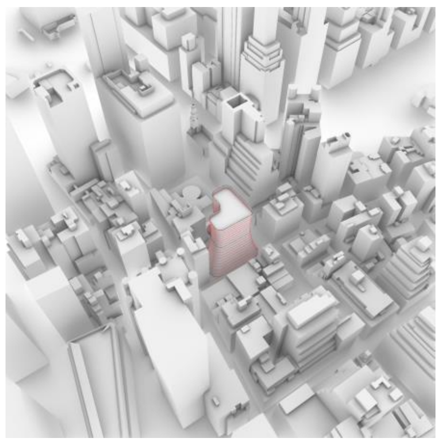


Figure 6: Curvy Building Iteration 2
As there are many ways to express curvature on the exterior of the building, this provides an alternative design strategy on how one could implement exterior curvature in the project.

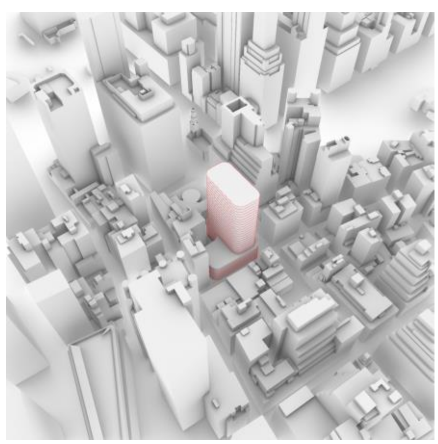


Figure 7: Curvy + Podium Iteration
Figure 7 represents an implementation of both curvature and podium features within the building design as a design strategy to compound its economic value.

If one takes it a step further by overlaying the findings of this research, then one may start to articulate the project in the way that's suggested in figure 8. See table 5 for the summary of features that are included in this project. From exterior geometries to interior architectural design features, the entire design decision process was shaped by the concept of value generation rather than the abstract notion of a good design. What this means is that good design decisions are no longer amenities of building but are key elements of a project that drives tangible value for the owner. By focusing on developing the project with features that have a track-record of generating value for the project, the architect and the owner will be able to achieve better alignment of interest and reduce the strain of value-engineering a project, as each design decision was made with value creation in mind.

Table 5: Summary of Features

Features	
Podium	👍
Public Space	👍
Curvature	👍
Increase number of office corners	👍
Mixed use	👍
Large column free space	👍
Well sized lobby with street presence	👍
Use LED as the dominate lobby material	👍

Note: 👍 *represents features that have been observed to have a positive value contribution to office buildings in New York City and are sequentially implemented in this example as shown in figures 8 to 15.*

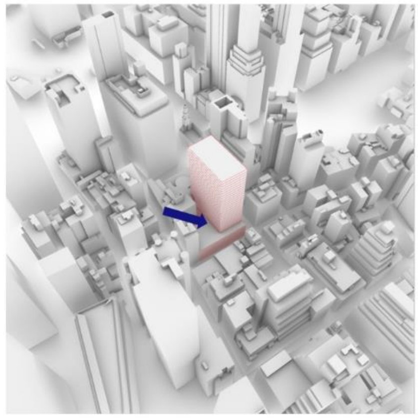


Figure 8: Podium
Note: The implementation in this step is to create a podium for the building as a way to capture the value premium and to create lower rooftop spaces that can be occupied as public or amenity spaces.

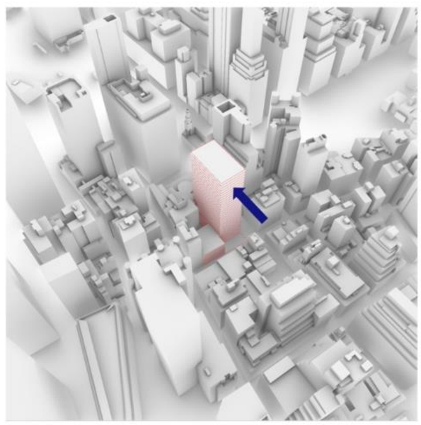


Figure 9: Public Space
Note: The building was pushed back from the intersection to create a public space that is welcoming to the public and the office tenants.

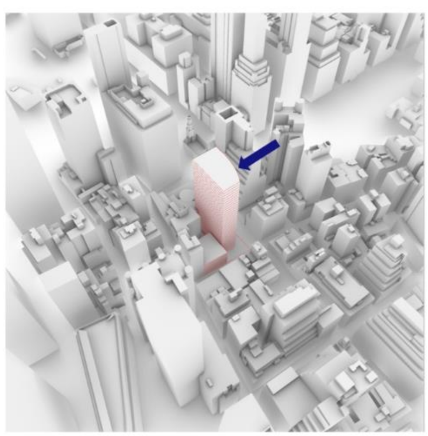


Figure 10: Curvature
Note: The exterior of the tower was tapered to create a curved façade that gently directs the traffic into the heart of the project.

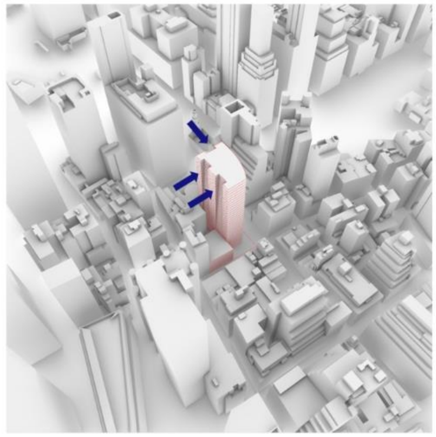


Figure 11: Increase Office Corners
Note: The profile of the tower was chiseled create more office corners per floor to increase its appeal to certain types of office tenants.

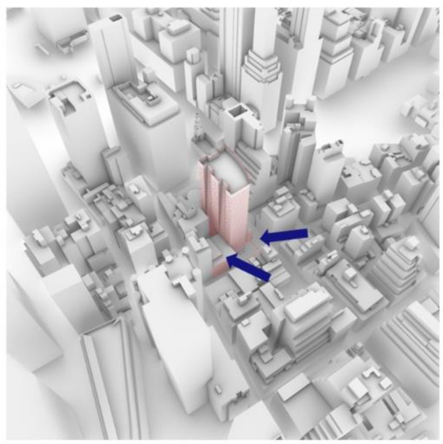


Figure 12: Mixed Use Programming
Note: The bottom floor of the building will be occupied by a good mix of retail tenants while the top of the podium will be used as a rooftop bar to introduce mixed programming to the project.

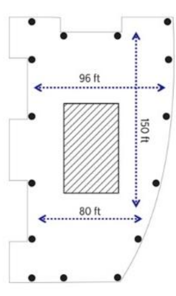


Figure 13: Large Column Free Space
Note: The interior of the office space is made up of large column free spaces to provide office tenants with spatial organization flexibility.

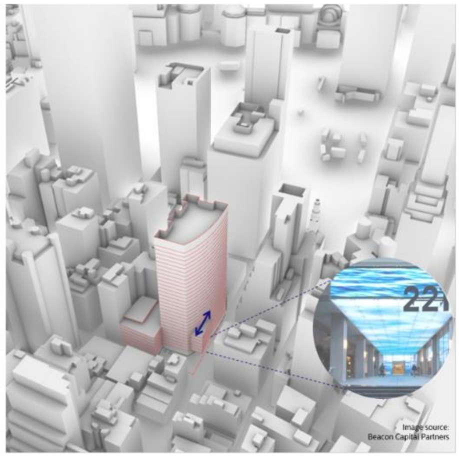


Figure 14: Good Lobby Presence
Note: The lobby of the building was extruded outward and designed to generate attention but not overly wasteful.

Figure 15: LED Displays as Main Lobby Material
Note: LED displays are the material of choice for the lobby interior to provide tenants with a modern experience of elegance and innovation.

6.3 Further Design Speculations

Although the findings that were presented in this paper are a big step towards quantifying the value of architectural design elements in real estate projects, it is simply a beginning of a trend in real estate where more and more market participants are using real estate data to drive their decision-making processes. As noted previously, in the current stage of the real estate industry it is extremely difficult to source quality data, and it is even more difficult to source quality building level data with many features; however, as data is currently becoming more readily available in the field, one could extrapolate that building related data will become more prevalent and more accessible. As the trend continues, this will enable the users of the data to create models akin to the ones that were performed in this research to derive more robust observations with more design features.

One could speculate that in the future more design features will be found to add tangible value to a property; as such, more buildings will be built with more architectural features that are relevant to the type of uses that the project is tailored for. In this case how would the design inform the data? Figure 16 illustrates a speculation on how a design that is derived from value-driven features could look. While there are tangible benefits of many of the features that are being suggested, such as having a double skin façade that aids the building's energy performance or having rooftop green spaces that allows the users of the building to be closer to nature, there isn't a place where one could source such data, and therefore one could only speculate on their value to the building. Table 5 is a summary of the features that are included within the design, with speculative features for future research.

Table 5: Summary of Features

Features	Speculative?
Podium	No
Public Space	No
Curvature	No
Increase number of office corners	No
Mixed use	No
Large column free space	No
Well sized lobby with street presence	No
Use LED as the dominate lobby material	No
Extremely good daylight	No
Efficient exoskeleton structure	Yes
Rooftop green space	Yes
Double-skin façade	Yes
Flex space	Yes
Plenty of fresh air	Yes
Good spatial variation	Yes
Wellness amenities	Yes

Note 1: represents features that have been observed to have a positive value contribution.
Note 2: represents speculative features that have not been observed to have a positive value contribution, but due to its positive qualitative value they are implemented within the speculative design. These are features that I am proposing that one should collect more data on in the future to evaluate whether they have been shown to quantitatively contribute to the transaction value of the building.

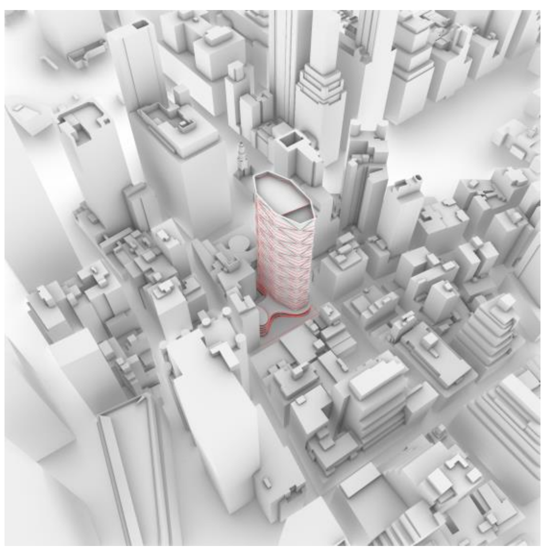


Figure 17: Speculative Design
Note: This depicts an implementation of the various design features that are outlined in Table 5.

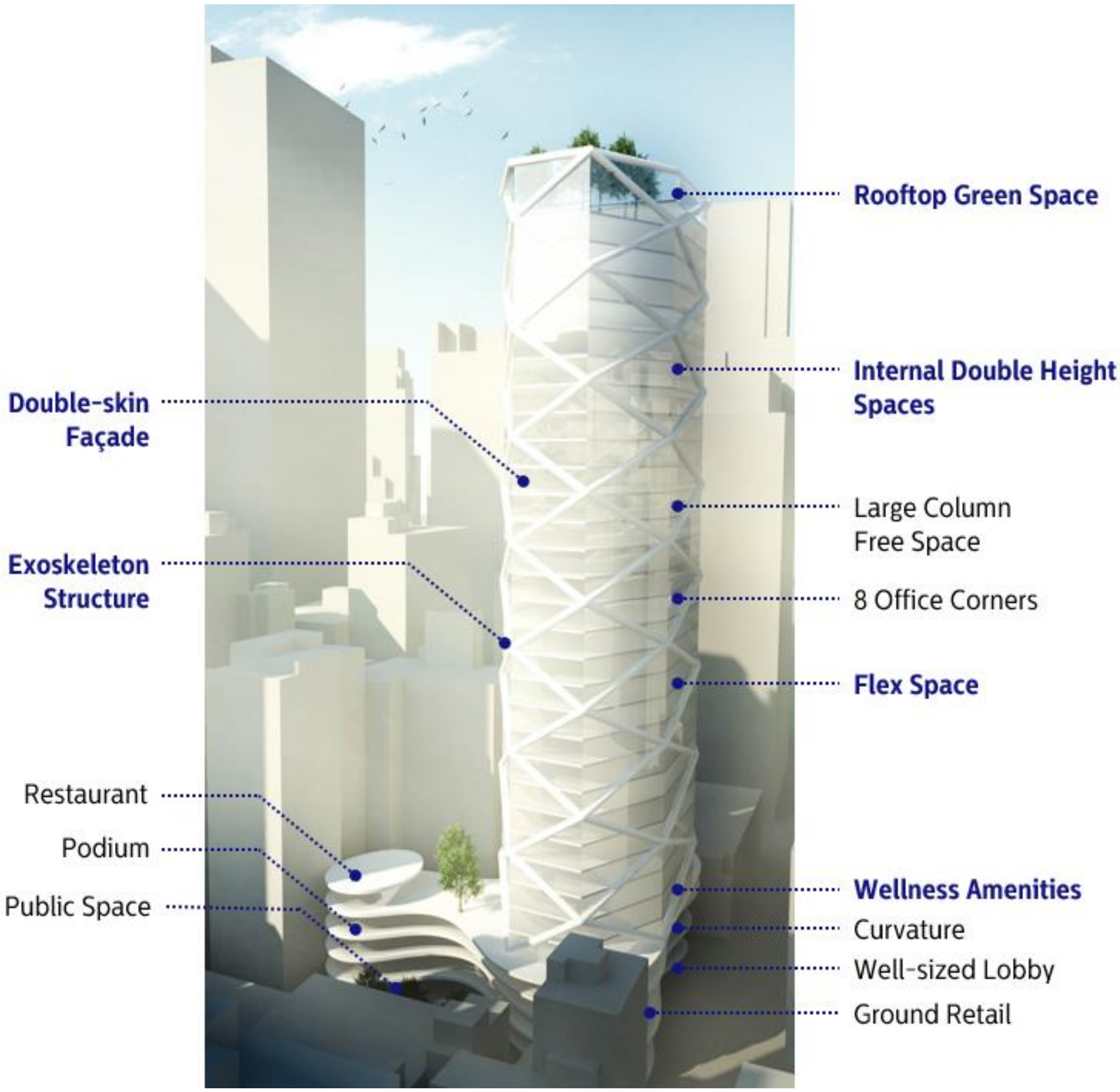


Figure 17: Speculative Design Render
Note: Features with black labels are design features that have been observed to increase the transaction price of a property. Features with purple labels are design features that contributes positively qualitatively to the property but have yet been shown to increase the property's transaction value through statistical models.

7. Conclusion

In this research, I measured design at a feature level to assess the impact of design decisions that were made by architects and developers. This study builds on existing research regarding the value of architectural design features by focusing on quantifying interior architectural design features and understanding their impact on the property's transacted price in New York City's commercial office market.

Out of the twenty design features measured, twelve design features were shown to be statistically significant in providing impacts on the property's transaction price. Out of the twelve, nine features had a positive impact – lobby width ratio, number of office corners, max edge to core distance, max edge to core distance (width), column-free, public space, mixed-use, and material choices for the lobby (LED, marble, masonry, or wood). The remaining three features had a negative impact on the property's transaction price – lobby area ratio, number of entrances, and lobby width. The fundamental difficulty of assessing the impact of an isolated variable is to control for other endogenous factors that also influence the transaction price; therefore, I used a hedonic pricing model and controlled for location and transaction time, simple building features, transaction features, and external building geometries. These models were able to explain 80 percent of the variation in transacted price, leaving limited room for omitted variable bias.

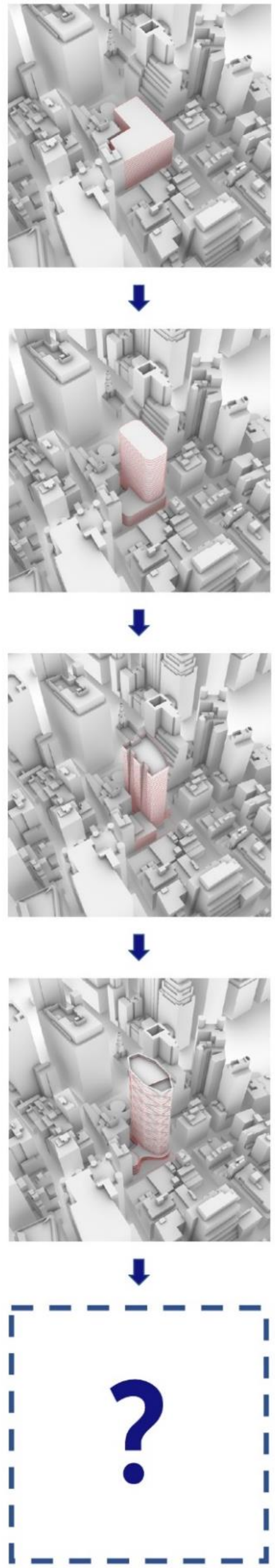
Based on the results, I provided examples of how one could implement such findings on a hypothetical site in New York City's Financial District. The result was a well-articulated building where every interior and exterior design features were implemented to provide a positive impact on the building's transaction value. Features that were included in that exercise were: podium, public space, exterior curvature, a greater number of office corners, mixed-use programming, large column-free interior space, well-sized lobby with good street presence, and the use of LED as the dominate lobby material.

Furthermore, I speculated on various architectural features that are contributors to the overall appeal of an office building but were not yet collected as quantified data and provided a speculative design proposal. There are many essential architectural elements that are needed to create an office space that is appealing to tenants: building's structural system, building enclosure, air exchange systems, temperature regulation systems, interior design elements, spatial sequence, just to name a few. While the existing set of design features that were investigated provides a good starting point, such a list of quantified design features would need to be greatly expanded to engender a robust set of feature-based evaluation and value-generating design strategies. In figure 18, I illustrated how the increase in the quantified design features can directly affect the design and how the project has continuously evolved as I layered on more data. As one continues to expand the set of value-contributing design features, the resultant project will also evolve and therefore the future iterations of the project may look drastically different than what is currently being proposed.

Further data collection, tests, and analysis are required to validate and improve the findings that were suggested in this study. Due to the inherent difficulty of collecting quality real estate data at the building level, the dataset that was used in this study was quite small. While the dataset was able to provide key insights into how building-level design features contribute to the property's transaction price, it certainly needs more observations for the user of the information to derive any robust results. As the field of real estate continues to evolve and quality data collection within the field becomes more prevalent, one can well expect that soon quality building level data will become more prevalent and more accessible to researchers and the public, therefore offering the opportunity to further validate and improve the findings of this study.

The contribution of this study is to create a relational understanding of architectural design features and real estate pricing. By providing insights into how design decisions impact the finance and economics of a building, it will allow architects and real estate developers to better align and deliver projects that can generate more value through relevant design features.

Figure 18: How will the design evolve as we gain more insights into architectural design features that generate economic value?



8. Bibliography

Chegut, Andrea M., et al. "The London Commercial Property Price Index." *The Journal of Real Estate Finance and Economics*, vol. 47, no. 4, July 2013, pp. 588–616.

Chegut, Andrea M., et al. "Spatial Dependence in International Office Markets." *The Journal of Real Estate Finance and Economics*, vol. 51, no. 2 (November 9, 2014): 317–350.

Chegut, Andrea M., et al. "The Value of Design in Real Estate Asset Pricing." *Massachusetts Institute of Technology*, 2019.

Fuerst, Franz, et al. "Designer Buildings and the Economic Value of Signature Architecture." *SSRN Electronic Journal*, 2009.

Geltner, David, et al. *Commercial Real Estate: Analysis and Investments*. OnCourse Learning, 2014.

Hough, Douglas, and Charles Kratz. "Can 'Good' Architecture Meet the Market Test?" *Journal of Urban Economics*, vol. 14, no. 1, July 1983, pp. 40–54.

Kang, Minkoo. "The Value of Design in Real Estate Development." *Massachusetts Institute of Technology*, 2019.

Millhouse, Jason A. "Assessing the Effect of Architectural Design on Real Estate Values: a Qualitative Approach." *Massachusetts Institute of Technology*, 2005.

Rosen, Sherwin. "Hedonic Prices and Implicit Markets: Product Differentiation in Pure Competition." *Journal of Political Economy*, vol. 82, no. 1, 1974, pp. 34–55., doi:10.1086/260169.

Turan, Irmak, et al. "The Value of Daylight in Office Spaces." *Building and Environment*, vol. 168, 2019, p. 106503.

Winston, Anna. "'98% Of What Gets Built Today Is Shit' Says Frank Gehry." *Dezeen*, Dezeen, 3 Oct. 2015, https://www.dezeen.com/2014/10/24/98-percent-of-architecture-is-bad-says-frank-gehry-middle-finger/.