# An Analysis of the Factors Affecting Light Industrial Property Valuation

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***Abstract*** **This paper uses statistical regression techniques to develop a model to explain both warehouse asking prices and warehouse quoted lease rates. In developing the statistical models, the paper provides a useful comparison between ordinary least squares (OLS), and weighted least squares (WLS) techniques. The results indicate that the market for industrial property is rational and that property characteristics determine the majority of the building value. The results also indicate the presence of a clientele effect between the market for industrial property listed for sale and property listed for lease.**

## Introduction

Traditional real estate valuation rests upon the principle that a property's value depends upon its characteristics. This principle is clearly evident in the traditional market comparison, cost and income approaches to valuation, as well as in statistical approaches to valuation.[1] This paper analyzes various light industrial property characteristics to examine explicitly which characteristics are associated with warehouse and light manufacturing rents and value. The study also provides an opportunity to examine a market segment that has received little research attention.

Statistical analysis provides a useful tool in analyzing the importance of property characteristics in value determination. Numerous earlier studies have examined the principle of multiple regression analysis as applied to real estate valuation. For example, Ratcliff and Swan [21] combine a price rating system with regression. Gloudemans and Miller [9] develop a regression analysis to study structural relationships of residential housing markets over time. Smith [25] uses statistical techniques to examine rural farms while Woolford and Cassin [31] use multiple regression analysis to value rural unimproved land.

Yet most multiple regression analysis is confined to residential properties that have large numbers of transactions. For example, Kamath and Yantek [14], Lang and Jones [17], Richardson and Thalheimer [23], Sweetland and Colclough [26], Reichert and Moore [22], Mark and Goldberg [19] and Ferreira and Sirmans [5] use regression techniques on single-family houses. Multiple regression analysis is also used to examine multifamily properties. For example, Shenkel [24] and Kang and Reichert [15] develop statistical models to value multifamily dwellings.

Other studies present techniques which attempt to account for the practical problems inherent in using multiple regressions on real estate data. For example, to deal with the problems of multicollinearity, Anderson [1], Newell [20], and Ferreira and Sirmans [5]

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examine the ridge regression technique which uses biased regression estimates. Gau and Kohlhepp [6, 7] and Vandell [28] discuss the use of principal components regression in dealing with multicollinearity. Gilley and Pace [8] suggest combining statistical models with the cost approach using the inequality restricted least squares estimator to reduce the problems with multicollinearity. In another area, Curcio, Gaines, Bennett and Webb [3] use Bayesian regression techniques to increase the efficiency of regression estimates. Donnelly [4] shows that the use of nonlinear regression in housing value assessment does not produce significant improvement over linear regression. Colwell, Cannaday and Wu [2] and Lipscombe and Gray [18] suggest an adjustment grid method similar to regression analysis which avoids the omitted variables problem.[2] In examining the issue of small sample sizes, Kuhle and Moorehead [16] discuss the use of bootstrap statistical techniques with small real estate sample data.

Unfortunately, for the most part, industrial property is ignored in the literature. Problems with collecting data and small sample sizes hamper the study of industrial property. In one study, Hoag [10] uses industrial real estate in an attempt to develop an index of real estate value and return. Yet little other work exists in the area of examining industrial properties due to the lack of information concerning these properties. Thus this paper extends the use of multiple regression valuation techniques to an area that has received little research attention.

The paper is organized as follows. Section two discusses the characteristics of industrial property and why multiple regression is applicable to examining industrial property. Section three provides a description of the data used in the study. The fourth section discusses the methodology and section five presents the regression results. Finally, section six summarizes the findings of this study.

## Industrial Property

According to Holmes [11]:

> Industrial property may be defined as the land, structural improvements, and equipment connected with a particular property which is being used for the conversion of materials into finished manufactured products. Broadly speaking, warehouses and minor processing plants of all kinds are included in the category of industrial property.[3]

For the purposes of this study, industrial property is defined as light manufacturing and warehouse space containing varying amounts of office space. These properties are usually concentrated along major transportation routes and confined to light industrial/commercial complexes.

Financial theory implies that a 'rational' manager's objective is to maximize the wealth of present shareholders and that managers make decisions based on economic factors in order to achieve this goal. This implies that the participants in the industrial property market behave in an economically rational or sophisticated manner. Thus businesses view the location decision as a necessary business cost to be minimized in light of their profit maximizing goal. Given that financial factors and property characteristics play such an important role in location decisions, it is expected that industrial property value is highly correlated with the property characteristics.[4] Therefore, industrial property, where great importance is placed on the property's physical and economic characteristics, is an excellent candidate for statistical analysis.

Past studies have well documented the relationship between property value and physical characteristics. For example, in analyzing residential properties the sales price is often regressed against the number of bedrooms, the number of bathrooms, property age, the presence of a basement and other amenities.[5] This study examines the relationship between characteristics specific to light industrial property and value.[6] In discussing the cost approach to appraising industrial property, Treadwell [27] notes that value will depend on size, ceiling height, the number of truck doors and other factors specific to industrial properties.[7] In examining the factors impacting on the asking price, the following linear equation is specified:

$$ASKING\ PRICE = f(BLDSQFT,\ OFFICE,\ BTS,\ CEILING,\ DOCK,\ DRIVE,\ RAIL,\ SPR,\ GEN)$$

where:

| | | |
|---|---|---|
| *ASKING PRICE* | = | total sales price quoted by brokers, |
| *BLDSQFT* | = | building size in square feet, |
| *OFFICE* | = | office space in square feet, |
| *BTS* | = | presence of build-to-suit office space, |
| *CEILING* | = | ceiling height in the warehouse, |
| *DOCK* | = | the number of dock-high doors, |
| *DRIVE* | = | the number of drive-in doors, |
| *RAIL* | = | the presence of a railroad siding, |
| *SPR* | = | the presence of sprinklers, |
| *GEN* | = | a proxy for building age. |

In order to examine the factors that impact the quoted lease rate, the following linear equation is specified:

$$ASKING\ RENT = f\ (AVASPACE,\ OFFICE,\ BTS,\ CEILING,\ DOCK,\ DRIVE,\ RAIL,\ SPR,\ GEN)$$

where *ASKING RENT* is the quoted rent per square foot and *AVASPACE* equals the total square feet available for lease and all other variables are the same as above.

Exhibit 1 lists the variables used in the study along with their expected sign. In the asking sales price models, all the variables except *GEN*, which proxies for the building age, are expected to have positive signs. Building age is expected to be negatively related to sales price. In examining quoted rents, building size (*AVASPACE*) is expected to be negatively related to rents. The rational is that, as the lease size increases, tenants receive the equivalent of a volume discount on the lease space. All the other variables are expected to have the same sign as in the asking sales price regressions.

## Sample Data

The sample data used in this study is a subset of a database consisting of properties listed with industrial real estate brokers in the Atlanta area.[8] Each broker is contacted on a monthly basis to update and assure the accuracy of the information in the database. Local

**Exhibit 1**
**Variable Definitions**

| Variable | Expected Sign | Description |
|---|---|---|
| *ASKING PRICE* | | total asking sales price quoted by the broker. |
| *ASKING RENT* | | asking rent per square foot quoted the broker. |
| *BLDSQFT* | [+] | total building square feet available for sale. |
| *CEILING* | [+] | ceiling height in the warehouse. |
| *DOCK* | [+] | the number of truck dock-high doors available. |
| *DRIVE* | [+] | the number of drive-in doors available. |
| *GEN* | [−] | dichotomous internal database variable expressing the generation of the space. All new and never occupied space is denoted as first generation and is coded as 0. All other space is defined as second generation and coded as 1. |
| *LAND*[1] | | total acreage of the property site. |
| *AVASPACE* | [−] | total contiguous square feet available for lease. |
| *OFFICE* | [+] | total square feet of office space available in the building. |
| *RAIL* | [+] | dichotomous variable denoting the presence of a railroad siding. |
| *SPR* | [+] | dichotomous variable denoting the presence of a sprinkler system. |
| *YRBLT*[2] | | the year the building was built. |
| *BTS* | [+] | dichotomous variable denoting build-to-suit office space. Properties with BTS of 1, are coded as having 0 square feet of OFFICE space. |

[1] *LAND* is reported only for descriptive purposes and is not used in the analysis due to lack of data.
[2] *YRBLT* is not used in the analysis since the variable *GEN* accounts for building age and condition.

newspapers and trade publications are constantly screened and, periodically, the area is physically examined for new additions to the market. Thus the database is considered to contain the population of industrial space on the market.[9]

The sample data consists of a listing of industrial properties located in the northeast area of metropolitan Atlanta during 1986 and 1987. Most of the warehouses are located in a narrow corridor along an interstate highway and a major industrial surface street. Since the subject properties are located in a concentrated area and interstate highway access is relatively constant, the data is assumed to be free of location bias. Although the results from this study should provide a general understanding of the light industrial property market, care must be taken in extending the models to properties in other areas due to the location-specific nature of the data.

The database consists of two parts: individual industrial properties listed for sale and contiguous industrial spaces listed for lease. The first part of this study examines the relationship between the property characteristics and the asking sales price. The next section examines the quoted rent per square foot in light of these characteristics.

Although using the asking sales price and rent is less desirable than using the actual market sales price and rent, data on the market prices and rents is not available for meaningful statistical comparisons. However, using quoted prices and rents as proxies for the market prices and rents is not without precedent. For example, Vandell and Lane [29] use quoted rental rates as a proxy for market rental rates to examine the impact of architectural quality on office rents.

The major problem with the use of asking prices and rents instead of market prices and rents is that it introduces a possible bias to the analysis. Asking prices typically tend to be higher than the actual market price since there is an assumption that the final sales price is negotiated down. Thus any results based on the asking price must be tempered with the realization that some potential bias may be present in the data.

Given this caveat, it is noted that the asking price and rent should be highly correlated with the actual market price and rent. Asking prices should be a good proxy for market prices. Most of the warehouses in the database are listed with professional industrial brokers, and, presumably, these brokers can estimate the market price. Since the brokers earn their commissions by selling and leasing the warehouses, they understand that an

## Exhibit 2
## Correlation Between Broker Quoted Data and Market Data

### Panel A: Sales Prices[1]
### Dependent Variable is Market Sales Price Regressed on Asking Price

| Variable | | Parameter Estimate[3] |
|---|---|---|
| Intercept | | 10749.000 |
| | | (0.144) |
| *Asking Price* | | 0.892* |
| | | (24.730) |
| *F*-statistic: | 611.571* | |
| $R^2$: | 0.987 | |
| Adjusted $R^2$: | 0.986 | |
| Observations: | 10 | |

### Panel B: Rental Rates[2]
### Dependent Variable is Market Rental Rate Regressed on Asking Rent

| Variable | | Parameter Estimate[3] |
|---|---|---|
| Intercept | | 0.317** |
| | | (1.665) |
| *Asking Rent* | | 0.915* |
| | | (27.354) |
| *F*-statistic: | 748.259* | |
| $R^2$: | 0.833 | |
| Adjusted $R^2$: | 0.832 | |
| Observations: | 152 | |

Notes:

[1]Sales prices are total market and asking sales price for each property.
[2]Rental rates are market and asking rent per square foot for each property.
[3]*t*-statistics are in parentheses.
*denotes significance at the 1% level
**denotes significance at the 10% level

asking price excessively above market expectations will drive prospective buyers away and that too low an asking price will reduce their commission. Thus rational behavior on the broker's part is to set the asking price (rent) as close as possible to the actual selling price (rent).

To examine the correlation between actual sales prices and quoted prices, actual sales data on ten warehouses were collected and compared to the asking prices. Exhibit 2 presents the results comparing market sales prices and rents with asking prices and rents. Regressing the asking price against the actual price produced an $R$-square of 98.71%. Similarly, actual rental rates available for 152 spaces were compared to the quoted rent for those spaces. Regressing the quoted rent against the actual rent produced an $R$-square of 83.30%. Given the strong relationship between the actual and quoted rents and prices, inferences obtained from using the quoted sales price and rental rates can be generalized to the market rates and prices.

The variables used in this study represent a subset of the property information contained in the database.[10] These variables include the relevant financial and property characteristics of each warehouse. Since the database is designed by industrial brokers, these variables are believed to be the most relevant property characteristics practitioners use in analyzing real estate.[11]

The *OFFICE* and *BTS* variables deserve further explanation. Office space (*OFFICE*) is recorded as total square feet of the building or available space devoted to finished office area. For some buildings, particularly new buildings, office space is listed as build-to-suit (*BTS*). This means the amount of finished office space is flexible and will be built to the tenant's (or buyer's) specifications. To control for this, all office space listed as build-to-suit is coded as having 0 square feet of office space (*OFFICE*) and a dichotomous dummy variable (*BTS*) is set to 1.

## Methodology

Since the warehouse property characteristics are assumed to follow a linear relationship to the asking price and rent, the first part of the study regresses the property characteristics on the dependent variable using ordinary least squares (OLS). In applied statistical analysis, the problems of heteroscedasticity and multicollinearity must be addressed.

Heteroscedasticity, the condition of having the error variance non-constant over all observations, is a common problem in applied statistics using cross-sectional data.[12] For example, in valuing warehouses, the building size is expected to have a positive impact on the sales price. Thus, as the building size increases, the warehouse value should also increase. Obviously, the value of a 100,000 square foot building will be greater than that of a 10,000 square foot building. Yet the difference in value of a 90,000 square foot building compared to a 100,000 square foot building will be smaller than the 10,000 square foot building. Thus the variance of the errors is not likely to be constant across all buildings with different sizes. For this reason, appraisal valuation is expected to be heteroscedastic.

The problem with heteroscedasticity is that the ordinary least squares (OLS) estimators are likely to result in a biased estimator for the covariance matrix. Although the OLS estimators are still unbiased and consistent, they are no longer the minimum variance unbiased estimators. Thus the estimators are inefficient and the variance estimates are biased.

To control for this condition, a weighted least squares (WLS) regression is often used. The WLS regression weights the generalized least squares (GLS) estimator for each observation by the inverse of the standard deviation of the residuals.[13] The WLS regression involves a four-step process. First, the least squares residuals, $\hat{e}$, are calculated using OLS. Next, the equation

$$\ln \hat{e}_t^2 = z'_t\alpha + v_t \quad (1)$$

is estimated, where $v_t = \ln(\hat{e}_t^2/\sigma_t^2)$, and $z'_t$ is a vector containing the $t^{th}$ observation of explanatory variables. Since the building size is expected to be the primary cause of the heteroscedasticity, the vector $z'$ contains the building size variable.[14] In the third step, each variance is estimated by $\sigma_t^2 = \exp\{z'_t\alpha\}$. Finally, the residual variance estimate is used as the weight in the generalized least squares estimate.

To test for the presence of heteroscedasticity, a common method employed is the White test. White [30] presents a consistent parameter covariance estimator in the presence of heteroscedastic disturbances. White shows that comparing the elements of this consistent covariance estimator with the usual covariance estimator provides a direct test for heteroscedasticity. White also shows that this test statistic is asymptotically distributed as chi-square.

As Mark and Goldberg [19] point out, any study of real estate value using multiple regression must also address the problem of multicollinearity. The presence of multicollinearity presents several problems including: (1) difficulty in obtaining precise estimates of the effect of the different variables, (2) the variable coefficients may not be significant when in fact the variables are important, and (3) the coefficients may also be sensitive to the addition or deletion of variables or the addition of new data.[15] In order to test for the presence of multicollinearity, the variance inflation factors (*VIF*) are presented. Variance inflation factors greater than 10 indicate that multicollinearity may be a problem. Principal components regression and ridge regression techniques are often employed to deal with the problems encountered when multicollinearity is present.[16] Results presented below show that multicollinearity is not a problem with data in this study.

In order to provide a meaningful base for comparison and point out the problems inherent in real estate research, the first part presents results using ordinary least squares regression (OLS). The weighted least squares regression (WLS) results are then compared to the OLS results.

## Regression Results

### *Asking Price*

Panel A of Exhibit 3 presents the descriptive statistics for the variables used in asking price regressions. The average warehouse in the sample contains 34,968 square feet, of which 4,018 square feet (11.5%) is finished office space and has a mean total asking price of $1,183,595. The warehouses were built between 1955 and 1987, with the average being 1980.[17] The warehouses have a mean of 2.2 dock-high doors and 1.5 drive-in doors. Approximately half of the buildings have a sprinkler system. The average industrial property in this sample has a ceiling height of 16.74 feet and range from 12 to 24 feet. These buildings represent a homogeneous set of warehouses in a suburban area of a major metropolitan region.

## Exhibit 3
## Panel A: Descriptive Statistics
## Warehouses Listed for Sale in Northeast Atlanta

| Variable | Mean | Std. Dev. | Min. | Max. | N |
|---|---|---|---|---|---|
| *BLDSQFT* | 34968.444 | 35652.071 | 3900.000 | 14219.000 | 63 |
| *OFFICE* | 4018.130 | 6006.750 | 0.000 | 24000.000 | 63 |
| *BTS* | 0.381 | 0.489 | 0.000 | 1.000 | 63 |
| *CEILING* | 16.738 | 3.341 | 12.000 | 24.000 | 63 |
| *RAIL* | 0.048 | 0.215 | 0.000 | 1.000 | 63 |
| *SPR* | 0.540 | 0.502 | 0.000 | 1.000 | 63 |
| *DOCK* | 2.230 | 3.649 | 0.000 | 20.000 | 61 |
| *DRIVE* | 1.492 | 2.030 | 0.000 | 12.000 | 61 |
| *GEN* | 0.698 | 0.463 | 0.000 | 1.000 | 63 |
| *YRBLT* | 1979.982 | 8.512 | 1955 | 1987 | 63 |
| *PRICE* | 1183595.340 | 1200007.803 | 126000.000 | 5700000.000 | 59 |
| *LAND* | 3.377 | 3.432 | 0.470 | 14.000 | 41 |

Note: *YRBLT* and *LAND* are not used in the regression models due to perfect collinearity and lack of observations respectively.

## Panel B: Correlation Matrix
## Warehouses Listed for Sale in Northeast Atlanta

| Variables: | *BLDSQFT* | *OFFICE* | *CEILING* | *DOCK* | *DRIVE* | *RAIL* | *SPR* | *GEN* | *BTS* | *VIF* [a] |
|---|---|---|---|---|---|---|---|---|---|---|
| *BLDSQFT* | 1.0000 | 0.2904 | 0.1647 | 0.5567 | −0.0606 | 0.3120 | 0.4011 | 0.2982 | −0.2810 | 2.0286 |
| *OFFICE* | | 1.0000 | 0.3179 | 0.4211 | −0.2558 | 0.1566 | 0.3430 | 0.4408 | −0.5290 | 1.9338 |
| *CEILING* | | | 1.0000 | 0.4472 | −0.1370 | 0.1751 | 0.2345 | 0.0524 | −0.0860 | 1.2025 |
| *DOCK* | | | | 1.0000 | −0.2765 | 0.1918 | 0.3766 | 0.2794 | −0.3578 | 2.2963 |
| *DRIVE* | | | | | 1.0000 | 0.1379 | −0.2161 | −0.2704 | 0.2972 | 1.2916 |
| *RAIL* | | | | | | 1.0000 | −0.0926 | 0.1469 | −0.1754 | 1.2734 |
| *SPR* | | | | | | | 1.0000 | 0.0870 | −0.1280 | 1.3649 |
| *GEN* | | | | | | | | 1.0000 | −0.7665 | 2.4596 |
| *BTS* | | | | | | | | | 1.0000 | 2.6694 |

[a]Variance Inflation Factor used to test for multicollinearity

Panel B of Exhibit 3 reports the Pearson correlation coefficients and the variance inflation factors (*VIF*) for the independent variables. The Pearson correlation results indicate that the variable build-to-suit (*BTS*) is correlated with the building generation (*GEN*) at −76.65%. This result is not surprising since first generation space is newly built and builders typically finish the office space to the tenant's specifications. Based on the variance inflation factors (*VIF*), the correlation between the independent variables does not present a serious problem. Generally, a *VIF* greater than 10 indicates the presence of multicollinearity in the data. Since the largest *VIF* equals 2.669, the data set does not appear to have a multicollinearity problem.

Exhibit 4 presents the results for the regression models, explaining the total asking price for industrial property. Model [1] reports the ordinary least squares (OLS) results of regressing the asking price on the property characteristics and provides a useful base for comparisons with the weighted least squares (WLS) model. In model [1], the variables

**Exhibit 4**
**Estimated Coefficient Values and *t*-Statistics for Ordinary Least Squares (OLS) and Weighted Least Squares (WLS). Dependent Variable is Asking Sales Price**

| Variable | [1] OLS | [2] WLS[a] |
|---|---|---|
| Intercept | 261768.842 | 494593.486 |
| | (0.76) | (0.68) |
| *BLDSQFT* | 11.708* | 9.366*** |
| | (5.54) | (1.73) |
| *OFFICE* | 83.988* | 61.367*** |
| | (6.34) | (1.89) |
| *CEILING* | −27061.753 | −21034.761 |
| | (−1.47) | (−0.69) |
| *DOCK* | 160783.725* | 110849.363*** |
| | (5.57) | (1.81) |
| *DRIVE* | 125308.566* | 90200.353 |
| | (4.33) | (1.45) |
| *RAIL* | 686846.429** | 750667.965*** |
| | (2.14) | (1.92) |
| *SPR* | 22366.346 | 338271.202 |
| | (0.18) | (1.38) |
| *GEN* | −56897.811 | 2529.677 |
| | (−0.32) | (0.01) |
| *BTS* | 324971.602*** | 32880.178 |
| | (1.87) | (0.09) |
| *R*-square | 0.888 | 0.794 |
| Adj. *R*-square | 0.866 | 0.755 |
| *F*-statistic | 41.193* | 20.154* |
| White's test | 38034.132* | 28.855 |
| Observations | 57 | 57 |

*significant at the 1% level
**significant at the 5% level
***significant at the 10% level
[a]WLS computed by scaling dependent and independent variables by the variance of the residuals

*BLDSQFT, OFFICE, DOCK, DRIVE* are significantly different from zero (at the 1% level) and carry the expected sign. The variable *RAIL* is statistically significant with the expected sign at the 5% level, and *BTS* is statistically significant with the expected sign at the 10% level. The model's *F*-statistic of 41.19 is significant at the 1% level, allowing rejection of the null hypothesis that all the parameter estimates are zero.

The model suggests that for each square foot increase in the building size (*BLDSQFT*), the asking price increases $11.71. The model also shows that each additional square foot of finished office space increases the asking price by $83.99. Interestingly, the presence of sprinkler systems and the ceiling height do not appear to affect the value, yet the presence of a railway siding does positively impact the asking price. The number of dock-high doors and drive-in doors in the warehouse has a significantly (at the 1% level) positive relation with asking price. The coefficients suggest that each dock-high door increases the asking price by $160,783.73 and each drive-in door increases the asking price by $125,308.57. Overall the model explains 86.6% of the variation in the asking price.

The presence of heteroscedasticity is tested by using White's test. The test statistic is asymptotically distributed as chi-square and tests the null hypothesis that heteroscedasticity is not present. The OLS model has a test statistic of 38034.132 which is significant at the 0.0001 level, indicating that heteroscedasticity is present in the model. To control for the heteroscedasticity present in the data set, model [2] in Exhibit 4 presents a Weighted Least Squares (WLS) regression.

The WLS regression is calculated by weighting the generalized least squares (GLS) regression equation by the inverse of the standard deviation of the residuals. The results show that the overall explanatory power of the model declines to 75.5%. The significance levels for the coefficients for all the variables change. In the WLS model only *BLDSQFT, OFFICE, DOCK* and *RAIL* are significant (at the 10% level) and have the expected sign. All other variables are not significantly different from zero. The WLS model *F*-statistic of 20.154 is significant at the 1% level, indicating that some variables are significantly different from zero.

### *Lease Rates*

In order to gain a better understanding of the industrial property market, the property characteristics discussed above are regressed on the quoted lease rents per square foot in an effort to determine which factors influence lease rates. Panels A and B of Exhibit 5 present the descriptive statistics and correlation matrix for the warehouse spaces listed for lease. The average warehouse space (or bay) contained 15,775 square feet with approximately 1,932 square feet (12.25%) of office space. The average rent for these spaces is $5.78 per square foot with a minimum of $2.20 and a maximum of $14.50 per square foot.

As with the properties listed for sale, the leased data does not exhibit extreme multicollinearity. Panel B shows that the building age, proxied by *GEN*, is correlated with build-to-suit (*BTS*) office space. *GEN* and *BTS* have a correlation of −71.9%, which is very similar to the warehouses listed for sale. Again, the variance inflation factors (*VIF*) do not indicate a problem with multicollinearity in the data.

Exhibit 6 presents the results of regressing the property characteristics against the quoted rent per square foot. The data used in these regressions are contiguous spaces listed as available for lease by industrial brokers. Out of 435 spaces listed for rent, 388 observations met the data availability requirements for inclusion in the study. The OLS model reports the results of regressing the property characteristics against rent per square foot as a base case. Only the railroad (*RAIL*) and available space (*AVASPACE*) variables are not statistically significant (at the 10% level). The variables *OFFICE, CEILING, GEN,* and *BTS* are significant at the 1% level while the variables *DOCK, DRIVE,* and *SPR* are significant at the 5% level. The results indicate that each additional square foot of office space raises the asking rental rate by $0.0002 per square foot. Each additional foot of ceiling height reduces the rental rate by $0.29 per square foot. The presence of a sprinkler system adds $0.35 to the asking rent per square foot and the ability to build office space to the tenant's need adds $1.65 per square foot. Older buildings are reduced in value by $0.77 per square foot. Interestingly, each drive-in door raises the asking rent per square foot by $0.09 while each dock-high door reduces quoted rent per square foot by $0.08.

**Exhibit 5**
**Panel A: Descriptive Statistics**
**Warehouses Leased in Northeast Atlanta**

| Variable | Mean | Std. Dev. | Min. | Max. | N |
|---|---|---|---|---|---|
| *AVASPACE* | 15775.000 | 20999.000 | 1000.000 | 192000.000 | 435 |
| *OFFICE* | 1932.000 | 3380.000 | 0.000 | 28000.000 | 434 |
| *CEILING* | 16.755 | 3.135 | 8.000 | 30.000 | 435 |
| *RAIL* | 0.028 | 0.164 | 0.000 | 1.000 | 435 |
| *SPR* | 0.649 | 0.478 | 0.000 | 1.000 | 433 |
| *DOCK* | 2.313 | 3.447 | 0.000 | 22.000 | 433 |
| *DRIVE* | 1.178 | 2.598 | 0.000 | 25.000 | 433 |
| *GEN* | 0.745 | 0.436 | 0.000 | 1.000 | 435 |
| *BTS* | 0.302 | 0.460 | 0.000 | 1.000 | 434 |
| *YRBLT* | 1980.871 | 5.862 | 1960 | 1987 | 373 |
| *QUOTED RENT* | 5.778 | 2.221 | 2.200 | 14.500 | 393 |

**Panel B: Correlation Matrix**
**Warehouses Leased in Northeast Atlanta**

| Variables: | *AVASPACE* | *OFFICE* | *CEILING* | *DOCK* | *DRIVE* | *RAIL* | *SPR* | *GEN* | *BTS* | *VIF* [1] |
|---|---|---|---|---|---|---|---|---|---|---|
| *AVASPACE* | 1.0000 | 0.2640 | 0.3916 | 0.6593 | 0.1552 | 0.2090 | 0.1697 | −0.2511 | 0.2752 | 2.810 |
| *OFFICE* | | 1.0000 | 0.0624 | 0.0808 | −0.1040 | −0.0037 | 0.0248 | 0.3125 | −0.3763 | 1.531 |
| *CEILING* | | | 1.0000 | 0.5386 | −0.3142 | 0.2355 | 0.2260 | 0.0334 | −0.0764 | 1.593 |
| *DOCK* | | | | 1.0000 | −0.2281 | 0.1931 | 0.2426 | −0.1325 | 0.1884 | 2.415 |
| *DRIVE* | | | | | 1.0000 | −0.0387 | −0.0412 | −0.3279 | 0.3414 | 1.603 |
| *RAIL* | | | | | | 1.0000 | −0.0232 | 0.0342 | −0.0190 | 1.124 |
| *SPR* | | | | | | | 1.0000 | −0.1180 | 0.1211 | 1.083 |
| *GEN* | | | | | | | | 1.0000 | −0.7190 | 2.151 |
| *BTS* | | | | | | | | | 1.0000 | 2.492 |

[1]Variance Inflation Factor used to test for multicollinearity

The negative signs for *CEILING* and *DOCK* are not expected. The model implies that as the ceiling height increases, the asking rent per square foot decreases. One explanation is that this is equivalent to placing a premium on office space, which has lower ceiling heights than warehouse space. Since most warehouse space contains dock-high doors, the number of doors is also a function of the size of the space. As the number of dock doors increases, the size of the space increases. Thus the number of dock doors may also be a proxy for the size of the space leased. The negative sign on the coefficient suggests that tenants receive a volume discount for larger spaces. Since the variable measuring the space size (*AVASPACE*) is insignificant, the number of dock-high doors may be a proxy for the size.

Again the White statistic is computed to determine if heteroscedasticity is present in the data. Since the test statistic equals 592.519, heteroscedasticity is assumed to be present in the data. Thus model [2] in Exhibit 6 presents the results of the weighted least squares (WLS) to correct for heteroscedasticity. As in the asking sales price model, the variables are weighted by the variance of the residuals. The explanatory power of the WLS model

**Exhibit 6**
**Estimated Coefficient Values and *t*-Statistics for Ordinary Least Squares (OLS) and Weighted Least Squares (WLS) Dependent Variable is Quoted Rent per Square Foot**

| Variable | [1] OLS | [2] WLS[a] |
|---|---|---|
| Intercept | 10.395* | 13.397* |
| | (16.08) | (12.69) |
| *AVASPACE* | −0.000002 | 0.00001 |
| | (−0.25) | (0.75) |
| *OFFICE* | 0.0002* | 0.00004 |
| | (5.00) | (0.52) |
| *CEILING* | −0.293* | −0.398* |
| | (−8.43) | (−7.69) |
| *DOCK* | −0.083** | 0.113* |
| | (−2.12) | (2.96) |
| *DRIVE* | 0.092** | 0.122 |
| | (2.36) | (1.58) |
| *RAIL* | −0.472 | −3.385** |
| | (−0.86) | (−2.30) |
| *SPR* | 0.354** | 0.942** |
| | (1.98) | (2.72) |
| *GEN* | −0.771* | −1.339** |
| | (−2.75) | (−2.25) |
| *BTS* | 1.650* | −0.267 |
| | (5.68) | (−0.43) |
| *R*-square | 0.474 | 0.248 |
| Adj. *R*-square | 0.462 | 0.230 |
| F-statistic | 37.890* | 132.824* |
| White's test | 592.519* | 103.653* |
| Observations | 388 | 388 |

*significant at the 1% level
**significant at the 5% level
***significant at the 10% level
[a]WLS calculated by scaling the variables by the variance of the residuals

declines to 23.0% from 46.2%. The model's *F*-statistic of 13.82 is significant at the 0.0001 level. Interestingly, *OFFICE, DRIVE* and *BTS* are no longer significant (at the 10% level). The variable *DOCK* now carries the expected positive sign, suggesting that dock-high doors increase the asking rent. The *CEILING* height still has a negative sign suggesting that true warehouse space is less costly on a square foot basis. The significant (at the 5% level) negative sign on the railroad (*RAIL*) variable is not expected. Again *RAIL* is apparently a proxy for very large industrial spaces since only the largest of warehouses have railroad spurs.[18]

The most interesting result of the WLS model is that it only explains 23.0% of the variation in the listed lease rate, whereas these same property characteristics explain 75.5% of the variation in listed asking prices.[19] One possible conclusion is that the quoted lease rate contains many nonproperty-specific factors. Examples of these factors include the amount of free rent offered, the current market vacancy rate or discounts given for different terms. This points out the necessity of examining lease-specific financing items and general market factors when studying industrial leases.

Another interesting result is the difference in significant factors explaining asking sales prices and asking rents. Only the variables *DOCK* and *RAIL* are significant in both models and *RAIL* carries opposite signs. These results suggest that a clientele effect may be present in the market for industrial properties. Businesses that purchase industrial space require larger and more specific spaces to meet their needs. Whereas, businesses that lease space tend to take smaller, standard type industrial space. For example, the average industrial property listed for sale is more than twice as large as the mean industrial property listed for lease (34,968 s.f. compared to 15, 775 s.f.). On the other hand, industrial properties listed for lease contain on average more office space than warehouses listed for sale (12.25% compared to 11.5%). The industrial properties listed for sale also have more drive-in doors and railroad sidings than properties listed for lease. Larger companies requiring large areas of warehouse space and less finished office space may opt to purchase industrial property rather than lease large amounts of warehouse space with expensive front office space. Smaller firms requiring 10,000 to 20,000 square feet of space may find it too costly to purchase a building. Smaller, start-up firms generally lack the financing necessary to purchase a building. These firms also require greater amounts of finished office space and can easily adapt to the standard industrial lease property. Thus the differences in the models may be due to a clientele effect.

## Conclusion

This study has examined the property-specific factors that are associated with asking prices and lease rates, using quoted asking prices and rents as proxies for the market transaction prices and rents. The study shows that the industrial property market is highly efficient where 75.5% of the variation in asking prices is due to property-specific characteristics. The results show that the building's size, the amount of office space, the number of dock-high and drive-in doors, the presence of a railway siding, and the ability to build-to-suit office space are important in determining the asking price for light industrial properties. Interestingly, the presence of a sprinkler system, the building's age and the warehouse ceiling height do not appear to have an impact on the property's value.

This study also used these property characteristics to examine the asking lease rates for light industrial properties. Factors important in determining the lease rates include the ceiling height, the number of dock-high doors, the presence of sprinklers and a railroad siding as well as the property's age. Surprisingly, the models indicate that property characteristics explain approximately 23% of the warehouse rent. This suggests that other factors are very important in determining the market rental rate for light industrial or warehouse property. Such factors might include the length of the lease, inflation adjustment factors, any free rent given, frequency of rate adjustment, current vacancy rates or a discount given for different terms.

This study has also uncovered evidence of a clientele effect in the light industrial property market. The regression results show that the property characteristics explaining asking sales prices and asking lease rates are different. Comparisons of the two samples show that properties listed for sale are over twice as large and have less finished office space than similar industrial properties listed for lease. This suggests that the participants in the market for industrial property place emphasis on different property characteristics depending on whether they are leasing or purchasing warehouse space.

## Notes

[1]For example, the market comparison approach requires the appraiser to examine a property, compare it to recently sold properties with similar characteristics, and adjust the comparable properties to make them identical to the subject property. Then the appraiser infers a market value for the subject property from the comparable properties' adjusted values.

[2]Although using an adjustment grid method results in improved prediction, it does not allow for useful analysis of the factors impacting value.

[3]Holmes [11], pg. 124.

[4]Shenkel [24] demonstrates the correlation between property characteristics and value for multifamily dwellings. Given that the industrial market is as sophisticated as the multifamily market, this expectation is reasonable.

[5]See Ferreira and Sirmans [5], Gloudemans and Miller [9], Kamath and Yantek [14], and Anderson [1].

[6]The warehouse characteristics used in this analysis are the set of quantifiable characteristics identified by industrial real estate brokers as important.

[7]One potential problem in using any type of regression analysis is model misspecification. This analysis is concerned with the impact of the physical property characteristics on value and thus has ignored the income producing potential of industrial property. Although inclusion of some measure for the income producing potential for each building would no doubt add explanatory power to the model, data of this nature was unavailable. Furthermore, the database used in this study contains only vacant warehouses listed for sale and therefore does not contain a listing of properties held for investment purposes.

[8]The data used in this study was provided by Real Property Data, a real estate information service located in Atlanta, Georgia.

[9]Conversations with Danny Levinson, president of Real Property Data, indicate that the database tracks approximately 97% of the industrial property in the Atlanta area.

[10]Information contained in the database that is excluded from this analysis includes specific location addresses, broker information, and internal database audit variables.

[11]Due to data availability problems, not all of the variables are included in the regression analysis.

[12]For a general discussion of heteroscedasticity, see Judge, et al. [12, 13].

[13]See Judge et al. [13], pg. 412–20 for a complete discussion of estimation techniques under heteroscedasticity.

[14]In the analysis of the lease rates, the residuals are regressed against the total square feet of space listed for lease.

[15]See Judge, Griffiths, Hill and Lee [12], pg. 453.

[16]For example, see Ferreira and Sirmans [5], Anderson [1], and Mark and Goldberg [19].

[17]Since the data comes from a relatively homogeneous set of new buildings located in a suburban area, care must be taken when comparing the results to older buildings located in a central business district.

[18]One possible explanation for the negative sign for *RAIL* is that tenants must pay rent for the area around the railroad door that in many cases has a low utilization rate.

[19]Caution must be used in making inferences between the asking sales price models and the asking rental rate models due to the differences in sample sizes.

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