AN EMPIRICAL APPROACH TO MEASURING REAL OPTIONS EMBEDDED WITHIN URBAN LAND VALUES: A COLLECTION OF ESSAYS

by

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(Under the Direction of Henry J. Munneke)

ABSTRACT

The central and unifying theme of this dissertation is the value of urban land and its effect on investments in durable capital. More specifically, because structures are expensive to build, have an extensive construction time, and are long lasting, investments in durable capital entail a significant degree of uncertainty and irreversibility. Therefore, models which explicitly account for these factors directly in the estimation process may contribute to a refined measurement and better understanding of urban land values.

One such model is the real options framework. Through the application of the principles of financial option pricing, this framework implies that land can be valued as the sum of the value of the land in its current use plus the value of an option to change the land to its highest and best use. Accordingly, the first chapter in this dissertation examines the estimation of the redevelopment option and explores the spatial relationship between real options and land values.

Attaining the highest and best use of improved urban land often entails redevelopment of the physical capital. When a structure has depreciated to the point that the value of the existing bundle of structure and land, plus demolition costs, is less than or equal to the price of vacant land, then redevelopment occurs through teardowns (in which the existing property is demolished and a new structure is built in its place). Other times, it might not be economically (or legally) feasible to remove the structure, so partial redevelopment occurs through renovations (where the existing structure remains but the interior and/or exterior is substantially remodeled). Accordingly, the second chapter in this dissertation studies the determinants of the mutual exclusive decision to redevelop physical capital either in whole (teardowns) or in part (renovations).

Overall, results from this dissertation contribute to a better understanding of urban land values by providing evidence of the true complexity of the urban spatial structure, providing new evidence that housing purchased for both teardowns and major renovations is valued only for the underlying land, and by capturing the spatial dynamics of real options as capitalized in urban land values.

INDEX WORDS: Real options, Land values, Redevelopment, Renovations

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DEDICATION

This dissertation is dedicated to Christy, Baker, Sawyer, Sonya, Debbie, and in memory of my father.

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CHAPTER 1

VALUING REAL OPTIONS IN REAL ESTATE

Abstract

Real options are capitalized into the value of numerous assets. Although the values of such options have been explored within a theoretical framework, few papers have attempted to empirically value these options. Using transaction data on improved single family residential properties, this paper attempts to estimate the capitalized value of the redevelopment option at the property level by incorporating the probability of redevelopment into non-spatial and spatial hedonic models. Results from the study reveal a substantial level of spatial variation in the probability of redevelopment as well as in the resulting option values, providing evidence of the true complexity of the urban spatial structure. Furthermore, the study provides new and strong evidence that housing purchased for redevelopment is valued only for the underlying land; a result which provides support for theoretical models of urban growth.

Introduction

The influences of economic, social, and legal forces, reflected in land values, guide the formation of our cities and the evolution of the urban economy, as well as generate revenue for local governance. Therefore, it is critical to continually improve and expand our understanding of land values. While land is typically valued for its physical and locational attributes, often neglected is the bundle of legal rights conveyed with land. Among these is the right without obligation to change the land use or intensity of physical capital employed on the land. Because this right is analogous to a financial call option, it can valued by applying the principles of financial option pricing through an investment analysis framework formally known as real options. Specifically, raw land contains a one-time option to develop the optimal structure at the optimal time (the *development option*), developed land contains an option to redevelop the existing improvements to a higher and better use (the *redevelopment option*), and both raw and developed land contain an option to sell or completely abandon the property (the *abandonment option*). Land values therefore should reflect the capitalized value of various real options. The existence of these options and the fact that land use decisions involve a high degree of irreversibility, uncertainty, illiquidity, and investor discretion in regards to investment timing, make land values particularly well suited to be modeled within the real option framework.

While the real option framework has been applied to many different fields, only a few papers attempt to empirically value these options within the context of real estate. Clapp, Jou & Lee (2012) significantly contributed to this line of research by introducing an innovative approach for measuring the value of the redevelopment option within the standard hedonic framework. The current study utilizes this new approach to explore the value of real options with improved single family residential land values and extends the analysis into a spatial context. In addition, this study provides refinements to the measurement of the redevelopment option, as well as tests the validity of the prior approach.

Results from this study provide strong support for theoretical models of urban growth and reveal the true complexity of the urban spatial structure where location plays a pivotal role in both land values and option values. In addition, the specification of the hedonic model in this paper provides new and strong evidence that property purchased for redevelopment is valued only for the underlying land, which is a fundamental principle of models of urban spatial growth.

To value the redevelopment option, the redevelopment decision itself must be modeled or a proxy measure for this decision must be identified. Based on theoretical models of urban growth and redevelopment, Brueckner (1980) and Wheaton (1982) first proposed the optimal redevelopment rule, which states that a property will be redeveloped when the value of the existing bundle of structure and land, plus demolition costs, is less than or equal to the price of vacant land. Within the current study, the redevelopment decision is directly modeled within the context of a non-spatial and spatial model. The probability of redevelopment is then incorporated into a hedonic model, where the impact of the probability on the property's price reveals the real option value.

One important contribution of the current study is the extension of the modeling of the redevelopment decision to a spatially flexible framework. Dye & McMillen (2007) and McMillen (2008) find that teardowns exhibit a great degree of spatial clustering. Furthermore, Helms (2003) concludes that renovation exhibits spatial dependence which standard econometric techniques cannot capture, and thus recommends the use of spatial models in redevelopment studies. This paper extends those studies by estimating spatial probit and spatial hedonic models, which both allow the estimated coefficients to vary across the urban space. Results from these models reveal how redevelopment probabilities and option values are spatially distributed across the urban space. This is an important contribution, because although theory provides general guidance regarding how these option values should vary with a specific property attribute (e.g.: proximity to CBD, lot size, structure age, etc.), it is currently unknown how option values vary spatially where numerous property, market, and locational attributes interact in potentially complex and competing ways.[1]

The remainder of this paper is organized as follows. The next section provides a brief review of the prior literature. Real option valuation models are discussed in the third section. The econometric models and data are detailed in sections four and five, respectively. An analysis of the results and maps of the estimated redevelopment probabilities and option values are presented in section six. The final section offers concluding remarks.

Literature Review

Brennan and Schwartz (1985) proposed the investment analysis framework now known as real options by applying principles of financial option pricing, as pioneered by Merton (1973) and Black & Scholes (1973), to real investment decisions. The authors use a mineral extraction example to demonstrate that the standard net present value (NPV) analysis would lead to non-optimal extraction of minerals because there is a value to waiting to invest that is lost once excavation begins.

Similarly, McDonald and Siegel (1986) assert that, because the standard NPV investment decision rule is only valid if the variance of the present value of the costs and future benefits are both zero, the rule should be modified to include a hurdle value of some positive amount. The

[1] For example, proximity to the CBD typically increases redevelopment option value, but CBD oriented properties also typically have smaller lot sizes and are more intensely developed, both of which decrease redevelopment option value.

authors conclude that it may be optimal to delay investment until benefits are at least twice the investment costs.

Development Option

The first application of real options in real estate land-use decisions was Titman (1985), which uses a real options approach to analyze development of vacant land. The study focuses on the optimal timing and scale of development, and proposes a theoretical model for land valuation that incorporates the value of waiting for new information. Results from the study help explain why some choice urban lots remain vacant (or are under-utilized as parking lots) while neighboring properties are densely developed. Williams (1991) contributes to this literature by proposing an analytical valuation model that adds another source of uncertainty, where both the revenues from the developed property and the cost of development are assumed to follow a geometric Weiner process.

Capozza and Sick (1994) combine option theory with monocentric urban economic theory in order to analyze the effect of changes in model parameters on the development of vacant land at the urban fringe. The authors conclude that urban land can be decomposed into five parts: the value of pure agricultural land, cost of conversion, value of growth, an uncertainty premium, and an accessibility premium. The development option is the sum of the growth and uncertainty terms. In contrast, agricultural prices decompose into only three components: the value of pure agricultural land, a growth premium, and an uncertainty premium. Again, the development option is the sum of the growth and uncertainty terms. Using this framework, the authors conclude that the value of agricultural land prices rises as the urban fringe approaches due to increases in the option value component of land value.

Grenadier (1996) combines a game-theoretic approach and a real options framework to explain why some markets experience building booms in the face of declining demand and property values. Grenadier shows that this is a rational response when the developer's option to build may effectively expire due to preemption by another development. Thus, although building in a declining market is harmful to the developer, it is less harmful than developing second in a declining market. As such, the real option framework provides a rational foundation for these seemingly irrational development patterns.[2]

Abandonment Option

Within the context of financial options, McDonald and Siegel (1986) offer conditions under which it is optimal to abandon the project when the selling price exceeds the project value by a positive amount. In a real estate context, Brueckner (1980) and Wheaton (1982), show that when the assumption of zero demolition cost is relaxed in models of urban spatial growth, it is possible for a building to be abandoned before redevelopment would occur. In regards to real estate development, Williams (1991) shows that negative or sufficiently small yet positive net cash flows can result in an optimal decision to abandon the property. The study also concludes that undeveloped land is abandoned sooner than developed land because undeveloped land is typically more costly to maintain on a net basis.

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[2] Subsequently, many empirical studies test the theories presented in this literature review, which provide clear evidence for the real options framework over alternative frameworks (such as simple risk aversion to future uncertainty) to explain why investment projects are delayed. Sommerville (2001) examines whether the development option should be modeled as a compound option, and finds that once building permits have been obtained, the development process typically proceeds to completion, thereby providing little support for treatment as a compound option. Cunningham (2006) finds a negative association between real estate development and price uncertainty, and positive association between land prices and uncertainty. Cunningham (2007) further finds that after the imposition of Urban Growth Boundary in Seattle area, price uncertainty no longer delays investment. Bulan et al. (2009) study condominium developments and find that increases in both idiosyncratic and systematic risk lead developers to delay new real estate investments.

Redevelopment Option

In their studies of urban spatial growth, Brueckner (1980) and Wheaton (1982) both depart from the assumption of a static model of urban development with perfectly malleable non-land capital used in the prior theoretical models by utilizing a dynamic approach that assumed durable structures. Although the authors make slightly different assumptions in their models (mainly regarding physical depreciation of the structures), they both arrive at the same conclusion: redevelopment will occur when the price of land for new development exceeds the price of land in its current use by the cost of demolition. Because this theory implies that properties purchased for redevelopment can be used to estimate the value of vacant urban land, the theory has made possible urban land value studies where there number of vacant lots is limited. Several other studies subsequently examine the redevelopment decision, but do not address estimation of the redevelopment option value.[3]

Real Option Valuation Models

The first empirical study to estimate the value of one of the real options capitalized into land values was Quigg (1993). Quigg's proposed development option model combines an analytical framework similar to Williams (1991) with an empirical approach, where numerous

[3] Rosenthal and Helsley (1994) empirically examine the redevelopment decision based on single-family residential housing. Assuming that demolition costs are insignificant, the authors provide evidence that the price of a property to be demolished upon sale is equivalent to that of the vacant land. Munneke (1996) extends this research, based on commercial and industrial properties. The study finds that the probability of redevelopment increases as the value of a parcel in its redeveloped state increases relative to its value in its current use. Capozza and Li (1994) analyze the redevelopment decision under uncertainty by extending the general model of McDonald & Siegel (1986) and focusing on the role of variable physical capital. Results from the study show that when intensity of physical capital can be changed and the future is uncertain, reservation rents increase, investment decisions are delayed, conversion time increases, and higher amounts of physical capital are employed. Written at the same time but using different assumptions, Childs et al. (1996) and Williams (1997) reach similar conclusions in regards to repeated redevelopment. While Williams assumes one property use and development over time, Childs et al. allows for a mix of property types and assumes instantaneous development. Both authors conclude that each subsequent redevelopment is less costly and therefore occurs more frequently and less extensively compared to the single redevelopment case. Childs et al. provide the additional finding that multiple property uses increase option values, particularly if the growth rates in the cash flows produced by the two uses are less correlated.

parameters are required either to be estimated using empirical data or to be assumed. The paper estimates that the development option value ranges from 1% to 30% of vacant land value (depending on land use) with a mean value of 6%.[4]

Grovenstein, Kau, & Munneke (2005) provide refinements to Quigg's approach, particularly by using empirical data to compute development cost elasticities. Sensitivity analyses performed on this parameter reveal that the cost elasticity has a major impact on the option value because of its key role in determining the optimal building size, and furthermore that the empirically estimated elasticities are inconsistent with the assumed values in Quigg (1993). Despite these differences, the study finds development option values very similar in magnitude to those of Quigg: 1% to 11% of vacant land value (depending on land use) with an average of 6.7%.[5]

In response to the substantial data requirements and to the apparent sensitivity of the results to certain key estimated or assumed parameters, recently there has been a movement away from those models towards a pure empirical approach to option valuation. For example, Ooi, Sirmans, & Turnbull (2006) exploit a natural experiment to estimate the development option value. The experiment arises from the Singapore government's sale of vacant land contingent upon the land being developed within a certain time frame (thereby precluding the option to hold the land for future development). These government land sales, which have been stripped of option value, are used in conjunction with private market auction sales, which have

[4] Quigg (1993) studied 2,700 vacant land transactions in Seattle, WA from 1977-1979. Development option estimates for specific property types were as follows: commercial (2.56% to 5.18%), industrial (2.19% to 29.80%), low density residential (1.17% to 11.20%), and high density residential (1.89% to 10.4%).

[5] Grovenstein, Kau, & Munneke (2005) studied 836 vacant land transactions in Chicago, IL from 1986-1993. Development option estimates for specific property types were as follows: commercial (2.10% to 8.03%), industrial (1.22% to 11.29%), and high density residential (10.48%).

the option value intact, to extract the development option. The study concludes that the development option represents 20% to 49% of land value.

Of particular relevance to the current study, Clapp, Jou & Lee (2012); Clapp & Salavei (2010); and Clapp, Salavei & Wong (2012)[6] show that the standard hedonic model can be modified to identify the redevelopment option value as separate from the value of the land and improvements. This empirical approach is intuitively appealing, because the option is explicitly accounted for in the model much like any other property attribute. In addition, because the approach has modest data requirements, it is quite accessible to most researchers.

The foundation of this hedonic approach to option valuation is the non-negative nature of financial options. Among other rights, land ownership conveys the right without obligation to redevelop the property, which is analogous to a financial call option. The value of the redevelopment option therefore is necessarily non-negative, because the owner will not rationally exercise the option unless it is in the money. This implies that it is plausible to model option value as an additional characteristic to the property's intrinsic value (the value of the property without the option). This approach allows the option value to contribute to the property's total value if positive, and allows the property's current use to equal total value when option value is zero.

The generalization of the hedonic model originally proposed by Clapp, Jou & Lee (2012) can be written as:

$$P_i = \alpha + \beta X_i + \gamma \bar{Q}_i + u_i \quad (1)$$

[6] Clapp, Jou & Lee (2012) rigorously derives their model from hedonic theory, Clapp & Salavei (2010) is an empirical test of the theory, and Clapp , Salavei & Wong (2012) provides a broader empirical test of the previous two papers.

where P_i is the natural logarithm of the price of the i^{th} parcel, X_i is a vector of structural, location, and market characteristics, and $\bar{Q}_i$ is a measure of intensity. [7] Intensity is defined by the authors as the ratio of structure per unit of land, representing a type of aggregation index constructed from the vector of hedonic characteristics. [8]

The authors demonstrate that a hedonic equilibrium exists in the presence of an additive call option given the sufficient (but not necessary) condition that the option value declines with the level of intensity. This condition is plausible because intensity increases with interior square footage and other amenities (which increases the value of the property in its current use but decreases option value) and decreases with building age and poorly built structures (which decreases the value of the property in its current use but increases option value). Furthermore, using simulations, Clapp, Jou & Lee (2012) show that an intensity measure can identify option value separately from building and land values even when option value comprises a small fraction of the property's overall value.

The authors propose three different measures of intensity to capture option value: economic intensity, physical intensity, and teardown intensity. Economic intensity is defined as the ratio of the tax assessed value of improvements to the tax assessed value of land. Physical intensity is defined as the ratio of the subject's interior square footage to the average interior square footage of nearby new construction. Teardown intensity is defined as the ratio of the number of properties recently torn down (or having teardown potential) within a given distance to the subject property to the number of all properties within that same distance. Of the three proposed intensity measures, the authors place primary emphasis on economic intensity, because

[7] This is the general form of the equation because the authors use a variety of transformations of intensity as well as interactions between intensity and the other explanatory variables.
[8] This is similar in spirit to the capital-land ratio or "capital intensity" measure utilized in studies such as Brueckner (1983) and Capozza and Li (1994).

building age, condition of the improvements, and the value of location (all of which are important to redevelopment decisions) should be reflected in the property's economic intensity. [9]

However, while an intensity variable has the advantage of being readily available, it is actually a indirect measure or proxy for the underlying redevelopment decision. Rather than rely on such an indirect measure, the current study explicitly models the redevelopment decision by estimating the probability of redevelopment. A probability-based real option value model would simply substitute the probability of redevelopment in place of the intensity measure in equation (1).[10] Such a price equation can be written in general form as

$$P_i = \alpha + \beta X_i + \gamma \Phi_i + u_i \tag{2}$$

where Φ_i is the probability of redevelopment.

The underlying redevelopment decision can be modeled as

$$I_i^* = \omega' V_i - \eta_i \tag{3}$$

where I_i* is the underlying response variable ($I = 1$ if $I_i* > 0$, otherwise $I = 0$), ω is a vector of parameters to be estimated, V_i represents the structural, locational, market characteristics and intensity measures that may determine whether a property is redeveloped, and $\eta_i \backsim N(0, \sigma^2)$. This equation can be thought of as a reduced-form equation, which appeals to the findings of prior literature that teardown status is endogenously determined. Properties prime for teardown are typically small, older homes on large lots with a favorable location. Given that all of these elements are captured by the other explanatory variables in the model, redevelopment therefore is endogenous to the model. This further supports the use of a probability-based measure which

[9] However, this may not be the case if the tax assessor does not accurately decompose total value into separate building and land values, if the assessed values are outdated relative to current market values (in most markets assessed values are only updated every few years), or if the assessment process is not taken seriously by the municipality (which is plausible in some areas given that tax assessors are often elected officials with no appraisal training, licensing, or professional experience requirements).

[10] Alternatively, it can be argued that the estimated probability of redevelopment is also a type of intensity measure.

appropriately treats the redevelopment decision as endogenous to capture option value when estimated within the hedonic framework,

The principal drawback to this approach is the additional data requirements necessitated by the probability estimation, which can be difficult to obtain in some circumstances.[11] In addition, prior research suggests that teardowns are unlikely to be randomly drawn from the full sample of properties and are therefore likely to exhibit selection bias when included in a regression model. Therefore, not controlling for selection bias would result in a misspecified model.

An additional source of model misspecification would result from simply including the probability of redevelopment into the hedonic model without modifying any of the other explanatory variables. Specifically, the typical specification of a hedonic model of house prices implicitly constrains the coefficients on the structural attributes (such as interior area, bedrooms, and bathrooms) to be equal for all properties in the sample. Since the sample in the current study contains both teardown and non-teardown properties, this assumption would violate a primary implication of Brueckner (1980) and Wheaton (1982) that structural characteristics should not significantly contribute to the value for properties purchased for redevelopment. As such, interaction terms between the estimated probability of redevelopment and the major structural attributes are included to allow for the structural coefficients to differ between teardown and non-teardown properties.

Combining the endogenous treatment of the redevelopment decision, the interaction terms between probability and the structural attributes, and the selection bias correction collectively result in a model closely resembling the endogenous switching model of Heckman

[11] Based on prior experience as well as conversations with other researchers, teardown data can be very difficult (if not practically impossible) to obtain from some municipalities.

(1976) and Lee, Madalla & Trost (1979), where the conditional price expectations are weighted by the probability of the conditional event to form an unconditional price equation.

Within the context of the current study, the price of an individual house can only be observed in one of two states of nature: either the house is a teardown (I_i = 1) or it is a non-teardown (I_i = 0). Therefore, the conditional price expectation of the price equation, conditional on the teardown status of the house, and including a selection bias correction, can be written as [12]

$$E(P_i|I=1) = \alpha_1 + \beta_1 X_{1i}^{ns} + \gamma_1 X_{1i}^{s} - \sigma_{1\eta}\left[\frac{\phi(\omega^* V_i^*)}{\Phi(\omega^* V_i^*)}\right] \qquad \text{(teardowns)} \qquad (4)$$

or

$$E(P_i|I=0) = \alpha_0 + \beta_0 X_{0i}^{ns} + \gamma_0 X_{0i}^{s} + \sigma_{0\eta}\left[\frac{\phi(\omega^* V_i^*)}{1-\Phi(\omega^* V_i^*)}\right] \qquad \text{(non-teardowns)} \qquad (5)$$

where P_i is the natural logarithm of the price of the i^{th} house, X_i has been partitioned into X_i^{ns} representing vectors of location, market, & non-structural property characteristics (although it does include age) and X_i^s representing a vector of structural property characteristics (except for age), ϕ is the standard normal probability density function (the selection correction variable)[13], Φ_i is the standard normal distribution function (the probability of redevelopment), and σ_η measures the covariance between the error term in regime *I* and the error term of the choice function.

Multiplying equation (4) by Φ_i (teardown probability) and equation (5) by (1 – Φ_i), adding the resulting equations together, allowing $X_{0i}^{ns} = X_{1i}^{ns} = X_i^{ns}$, and constraining only the parameters β for the non-structural characteristics of the house to be equivalent for teardowns and non-teardowns yields the following model to be estimated

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[12] See Miceli et al. (2002) for the full derivation of the endogenous switching model within an urban land value context.
[13] Flores-Lagunes & Schnier (2010) propose the use of an 'adjusted' inverse mills ratio in spatial autoregressive error models.

$$P_i = \alpha_0 + \beta X_i^{ns} + \gamma_1[X_{1i}^s(\Phi_i)] + \gamma_0[X_{0i}^s(1-\Phi_i)] + (\alpha_1 - \alpha_0)\Phi_i + (\sigma_{0\eta} - \sigma_{1\eta})\phi_i - \lambda_i \quad (6)$$

where estimates of ϕ (selection correction) and Φ_i (teardown probability) are obtained from the first-stage estimation of the reduced-form probit model of the redevelopment decision. It should be noted that to satisfy the rank and order conditions required to properly identify the parameters of interest in the second-stage hedonic model, several explanatory variables (particularly the intensity measures) are included in the probit model but are excluded from the hedonic model.

Spatial Models

Prior research has shown that location is a primary determinant of option values. For example, Capozza & Sick (1994) provide theoretical support that agricultural land values increase in response to the approaching urban fringe due to an increase in the development option component of land value. In addition, the empirical redevelopment studies of Dye & McMillen (2007) and McMillen (2008) find that some areas in a municipality experienced significant redevelopment while other areas experienced none at all.

To allow for this spatial variation, the probit and price equations are estimated in this paper using a conditionally parametric regression model (CPAR). The CPAR model, introduced by Cleveland & Grosse (1991), is actually a special case of locally weighted regression (LWR) where degrees of freedom are preserved by making the model parametric in some variables while other variables are constrained only to have smooth and continuous marginal effects (McMillen & Redfearn, 2010). Although CPAR is fully nonparametric (no assumptions are made regarding underlying probability distribution of the data and the only information provided to the estimator is that the dependent variable is a function of the independent variables), the model is actually estimated using iterations of standard weighted least squares (WLS), with one WLS regression for each observation.[14] Essentially, each observation is used as a target point for estimation by all the other observations which receive positive weight. This reveals the inherit nature of the CPAR estimator: it uses a local linear function to approximate a smooth and continuous nonlinear function. Because of the flexible nature of the model and its conservation of degrees of freedom, CPAR is considered to be a natural choice for modeling many spatial datasets (McMillen & Redfearn, 2010). Since this model has not been used extensively by prior studies, a brief overview of the estimator is briefly provided.[15]

Consider the standard hedonic model, where the sales price P_i for the i^{th} property is regressed on a vector of explanatory variables *X* (including all structural and non-structural characteristics for notational simplicity). CPAR partitions *X* into portions that are nonparametric (X_1) and conditionally parametric (X_2), as written below:

$$P_i = \alpha + \beta_1(X_1) + \beta_2(X_1)' X_2 + u_i \tag{7}$$

The CPAR estimator is derived by including only the X_1 variables (in this study, these are geographic location, represented by latitude and longitude coordinates) in the kernel weight function *K*, and then minimizing the below objective function with respect to α, β_1, and β_2:

$$\sum_{i=1}^{n} \Big(P_i - \alpha - \beta_1'(X_{1i} - X_1) - \beta_2' X_{2i} \Big)^2 K\left(\frac{X_{1i} - X_1}{h} \right) \tag{8}$$

where *h* is the window size that determines how many observations receive positive weight.[16] Following prior research, this study utilizes a tri-cubic kernel weight function for *K* and

[14] LWR and all its variants can be estimated by WLS. See McMillen & Redfearn (2010) for a detailed analysis of the various models.
[15] The presentation in this section is largely a reproduction of McMillen & Redfearn (2010). The CPAR model was introduced by Cleveland & Grosse (1991), statistical properties were examined in Severini & Wong (1992), the model was discussed and expanded in Hastie & Tibshirani (1993) and Cleveland (1994), and more recently the model has been applied in an urban study by McMillen & Redfearn (2010).
[16] Prior research has shown that choice of kernel function does not materially affect the results of LWR-based models. McMillen & Redfearn (2010) attribute this to the fact that all kernel functions share the same basic feature of placing more weight on nearby observations. That said, this paper utilizes the tri-cubic function for two primary

determines the optimal window size h by minimizing the generalized cross validation (GCV) statistic from Loader (1999). [17]

Estimating equation (8) results in the following parameter estimates:

$$\hat{\theta}(X) = \left[\sum_{i=1}^{n} K(\psi_{1i})\, Z_i\, Z_i'\right]^{-1} \sum_{i=1}^{n} K(\psi_{1i})\, Z_i'\, P_i \tag{9}$$

where, as implemented in this paper, K is the tri-cubic kernel weight function, $\psi_{1i} = \left[\dfrac{X_{1i} - X_i}{h}\right]$, Z includes a constant, X_1, and X_2, and where $\theta = (\alpha \;\; \beta_1 \;\; \beta_2)'$. As can be seen in equations (8) and (9), distance in the kernel function is defined in terms of X_1 alone, but all variables are included in the regression. This produces coefficient estimates that each vary with X_1. Therefore, each coefficient is free to vary among properties, as opposed to the fixed coefficient assumption of OLS-based hedonic models.

Summary of Econometric Strategy

The econometric strategy used in this paper can be concisely summarized as follows. The estimated probability of redevelopment from a standard (non-spatial) probit model will be added as an explanatory variable into a standard hedonic model. The hedonic model is then estimated via OLS and the redevelopment option value is calculated from the resulting coefficients on the probability variables. The study then repeats this process using CPAR versions of both the probit and hedonic models, where the CPAR models are estimated by standard weighted probit and

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reasons. First, it gives observations decreasing weight at an accelerating rate as distance from the regression point increases. This feature is desirable, assuming that the neighborhood effects of redevelopment activity are likely nonlinear. Secondly, the tri-cubic kernel function is the most commonly employed kernel in the previous research.

[17] McMillen & Redfearn (2010) conclude that fixed bandwidth (a fixed distance for all target points, where the number of observations used to estimated each target point varies) potentially produces problems with excessive smoothing when there are many observations available for estimation, and potentially produces high variation when there is sparse data available. Therefore, a fixed window size (a fixed number of observations for all target points, where the max distance varies for each target point) is generally preferable when analyzing spatial data. Accordingly, a fixed window size is utilized in this paper.

standard weighed least squares, respectively, iterated for each of the *n* observations in the sample. An individualized redevelopment option value for each property in the sample is constructed from the resulting coefficients on the probability variables.

Data

This study utilizes 5,505 improved single family residential sales transactions in the City of Miami (Dade County), Florida from 1999 to 2002, of which 406 (7.38% of the final sample) are classified as teardowns (where the house characteristics are observed just prior to it being demolished in anticipation of redevelopment) and 5,099 are classified as non-teardowns (where the house has not been redeveloped).[18] The data file was obtained from the office of the Miami-Dade County unified government tax assessor. For each property in the county, the file contains physical characteristics, sales transaction data, as well as tax assessed values. The time frame of the sample utilized in this paper was chosen specifically to avoid potentially conflating effects of hurricane-related redevelopment and to quantify option values during an era of relatively stable house prices (thereby avoiding both the hyper-appreciation of the mid 2000s and the subsequent collapse of house prices in the late 2000s).[19] Data filters applied to obtain the final sample are similar to those commonly used in the prior literature and include the following: single-family structure (defined by state and county single-family residential land uses), sale must be a arms-length transaction with a sale amount greater than $50,000, owner must be the feeholder (no land leases), 300 sf minimum interior area, 1,500 sf minimum lot size, structure must contain more

[18] Teardowns comprise 7.8% of the final sample in Rosenthal & Helsley (1994), 3.8% in Munneke (1996), 12.6% in Dye & McMillen (2007), 17.6 % in McMillen (2008), and 3.8% in Clapp & Salavei (2010).

[19] The major hurricanes effecting Miami around the sample time period were Hurricane Andrew (Category 4, 1992) and Hurricane Wilma (Category 3, 2005). Hurricane Andrew was particularly destructive, where a significant number of homes across Dade County were damaged or destroyed. Hurricane data was obtained from the NOAA (National Oceanic and Atmospheric Administration).

than one bedroom and three or more total rooms, structure must be built after 1901, valid sales transaction data must be present, and tax assessed values must be present.

To improve the robustness of teardown identification, two data sources are utilized. As in other studies of redevelopment, demolition permits were obtained from the City of Miami Building Department. In addition, teardowns were identified by constructing a panel data set from the real property tax roll files for Miami-Dade County obtained from the Florida Department of Revenue. This file contains property-level measures such as year built, interior square footage, lot size, land use, the value of any improvements removed or added during the year, as well as sales transaction data and assessed value data reported on an annual basis. Accordingly, by observing the changing physical attributes of a property over time, this approach allows researchers to identify teardowns without an exhaustive list of demolition permits. When the panel teardown list is compared against the demolition permit file, this approach successfully captured 93% of the demolition permits for properties common to both the demolition permit list and the Department of Revenue files during the sample time frame.[20] Specific details of the teardown identification procedure are provided in the Appendix.

The descriptive statistics for the sample are reported in Table 1.1. The data appear to support the importance of intensity measures rather than absolute measures of property attributes in the teardown decision. Based on mean differences, the data indicate no significant difference between teardowns and non-teardowns in regards to the level of structural characteristics (*bldg_sf*, *bedrooms*, *bathrooms, and floors>1*). However, there is a significant difference in *lot_sf* (mean teardown lot sizes are 14% larger than non-teardowns). The data also suggest a significant difference in the relative relationship between the structure and land; both physical

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[20] A review of the permits not identified by our approach indicate idiosyncratic issues were the cause of non-identification rather than systematic differences that could be modeled.

intensity measures (*phy_int* and *lowest_ phy_int*) are statistically different at the 1% level. Additionally, the data indicate that the two economic intensity measures (*econ_int* and *lowest_econ_int*) as well as *ptear* (number of teardowns within .75 miles that occurred during the 3 years prior to the sale of the subject, divided by all sales within .75 miles of the subject) are also significantly different between the two sub-samples. Therefore, the univariate analysis suggests that teardowns are less intensely developed, have a greater percentage of observations with low levels of intensity, and are located in closer proximity to other teardowns when compared to the non-teardown properties. As such, the intensity variables are important explanatory variables to utilize in the first stage probit models to predict the probability of redevelopment.

The descriptive statistics also support prior findings that teardown structures are older, with larger lots, located closer to amenities (the CBD, the coast, golf courses, the hotel district, and the trendy residential and retail district known as Coconut Grove) and are located further away from disamenities (such as Miami International Airport). The significance of the locational measures suggests that redevelopment occurs in spatial clusters, rather than being randomly or evenly distributed across the urban space. These findings further suggest the use of spatial econometric models, which allow the estimated coefficients to vary across the urban space and minimize issues relating to spatial autocorrelation.

Theory suggests that the difference between the characteristics of the subject property and that of nearby new construction is an important consideration in the teardown decision. Therefore, this study compares the subject property to its immediate neighbors in terms of age, and to recent nearby construction in terms of interior area, as motivated by similar measures used in McMillen (2008). *Relative_age* is calculated as *age* divided by the mean *age* of homes within

.75 miles, *Relative_bldg* is calculated as *bld_sf* divided by the mean *bld_sf* of homes with .75 miles and built after 1990, and *relative_lot* is calculated in a similar manner. In the descriptive statistics, two of the relative neighborhood measures, *relative_age* and *relative_bldg*, reveal statistically significant differences. These results suggest that teardowns are older and smaller relative to the other homes and new homes in the immediate neighborhood, respectively.

Results

Probit Models

The redevelopment decision underlying the redevelopment option is empirically modeled within this study using a probit model. The results from the standard probit model, presented in Table 1.2, indicate that the probability of redevelopment appears to be driven by the age of the structure, and the parcel's locational attributes, and the intensity measures. The positive coefficient on *age99* (age of the house in 1999) confirms the well established finding in the redevelopment literature that as a property ages it becomes a more likely candidate for redevelopment. The coefficients on the various amenity dummy variables (*near_golf, hotel_district, Coconut_Grove*) are positive and significant, indicating that each increases the likelihood of redevelopment, which is consistent with the findings from previous studies where teardown candidates are typically found to be older properties in close proximity to recreational, cultural, and natural amenities. The coefficient on the *dist_CBD* variable, which represents the distance from CBD, is negative and significant, but only at a 10% level. This finding is consistent with the gentrification literature, where high income households redevelop CBD-oriented housing in order to live closer to the employment centers and enjoy the cultural amenities offered downtown.

A new contribution to the literature is the finding that the intensity measures appear to explain redevelopment better than the absolute measures of the singular property attributes. Both measures of economic intensity (*ln(econ_int)*, *lowest_econ_int*) are statistically significant and have the expected signs. However, the explanatory power of physical intensity (*phy_int*) seems to be concentrated in the lowest 10% of values (*lowest_phy_int*). The teardown intensity measure *ptear* is positive and significant, suggesting that redevelopment is likely to occur in areas that have already experienced redevelopment in the recent past. Therefore, while most of the intensity measures are statistically significant and have the expected signs in the standard probit, the structural attributes and lot size measure are statistically insignificant.[21]

These results indicate that the intensity measures are important determinants of the redevelopment decision, which provides strong support for the theory of Clapp, Jou & Lee (2012). However, it is important to note that not just one, but all three of the intensity measures are statistically significant in the probit model, suggesting that the redevelopment decision cannot be fully captured by a single attribute or ratio. This finding underscores the appeal of a probability based measure which constructs an index from the property's structural attributes, intensity measures, and locational characteristics.

Furthermore, probability can also incorporate relative neighborhood measures, which compares the subject property to average characteristics of the immediate neighborhood around it. Two of these variables, *relative_age99* and *relative_lot,* are significant but negative (at the 10% level). The unexpected negative signs curiously suggest that the likelihood of redevelopment decreases as a structure's age exceeds the average age of nearby structures and as

[21] It should be noted that when these intensity measures are excluded, *lot_sf* and *bldg_sf* are statistically significant, as in other teardown studies. Therefore, the explanatory power of these variables are captured by the intensity measures. Furthermore, variance inflation factor and condition index diagnostic tests indicate that using a combination of intensity variables in the probit does not produce significant multicollinearity concerns.

a property's lot size is larger than the average lot size of recent nearby new construction, respectively. It can be conjectured that these findings suggest that the oldest structures in an area may have some historic or neighborhood significance which would deter redevelopment. Alternatively, long-time property owners may be unlikely to redevelop the existing structure due to sentimental reasons, physical constraints, or limited financial resources. The other two relative neighborhood measures (*relative_bldg* and the interaction term *relative_age99*relative_bldg*) are statistically insignificant.

To explicitly incorporate the findings of prior literature which find that redevelopment occurs in spatial clusters and is a localized phenomenon, the coefficients in the probit can be allowed to vary across space and be estimated specifically for each individual observation through the use of spatial models. Accordingly, this study repeats the specification of the standard probit within a spatial framework. The CPAR models utilized in this study are estimated using an approximately 15% window size (each property is estimated using the closest 787 observations). The window size, which was selected by the data based on minimizing the GCV score computed from many different alternative window sizes, equates to an average radius of 1.23 miles (0.77 mile minimum, 2.34 mile maximum, and 0.27 mile standard deviation).

A concern in any spatial regression models is that of boundary effects. When observations are located near the boundary of a municipality, the number of nearby observations decreases which potentially induces substantial variation in the estimated coefficients. Therefore, buffer observations from other nearby municipalities are used to address the potential for edge effects to influence the results.[22] By using buffer observations, the windows are allowed to cross municipality boundaries, providing stability to the observations within the study area.

[22] The same data filters are applied to these buffer observations that are applied to the primary sample.

Consequently, municipality control variables are used in both the probit and value CPAR models (results for these variables are not reported).

CPAR is estimated by standard WLS with one regression for each observation, resulting in property level coefficients for each of the i^{th} properties (target points) in the sample. Although the estimated spatially varying property level results are of primary interest in this study, it is also possible to generate mean level results which are analogous to the coefficients reported in standard probit and OLS models. In this regard, the reported coefficient for an explanatory variable in the CPAR model is simply the mean value across the *n* estimated WLS models. Hypothesis testing of these results are the standard t-tests reported for WLS. Furthermore, because each target point has a longitude and latitude coordinate, the coefficient on any explanatory variable (as well as its statistical significance) can be plotted using GIS software.

Hypothesis testing for the mean level results is more complicated than in standard WLS. Following prior LWR research, the Cleveland and Devlin (1988) F-test is used in this paper to test the null hypothesis that a variable adds no explanatory power to this nonparametric model across the whole sample.[23] To form counterparts to standard t-statistics, the CPAR model is estimated *n* times with one variable omitted from the model. The resulting p-values from these tests are analogous to the results of a standard t-test of the null hypothesis that the coefficients equal zero (McMillen & Redfearn, 2010).

The results from the CPAR probit model turn out to be similar in many respects to that of the standard probit, where the structure's age, the intensity variables, and locational attributes are statistically significant explanatory variables in the model of the redevelopment decision. However, variables gaining statistical significance in the spatial probit at the 5% level are

[23] The test is comparable to a standard F-test, and has nearly the same form, where an explanatory variable is dropped and the CPAR model is re-estimated for all *n* iterations. Although the details of the test are omitted here, the reader is referred to McMillen & Redfearn (2010) for a thorough discussion.

bedrooms (negative mean coefficient), the *dist_from_CBD* (negative mean coefficient), the interaction term *relative_age99*relative_bldg* (negative mean coefficient) and *relative_lot* (negative mean coefficient). These results indicate that each of these variables decreases the likelihood of redevelopment. The first two are well established findings in the redevelopment literature, whereas the latter two respectively suggest that the effect of a property's relative age and interior area compared to new construction are interdependent and that lot size relative to new construction is important to the redevelopment decision.

Variables that are statistically significant in the standard probit that lose statistical significance in the spatial probit at the 5% level are *hotel_district* and *ptear*. These findings may suggest that the spatial model incorporates these locational fixed effects by limiting the sample to only nearby transactions. It is therefore reasonable to conclude that one reason why the magnitude of coefficients differs between the standard model and spatial models is that the latter essentially control for locational fixed effects.

While the results from the standard probit and CPAR probit models are similar in some respects, they are remarkably different in other very important respects. In particular, the standard deviation of the CPAR estimates indicate substantial variation, which suggests that the standard probit model's assumption that the estimated coefficients are constant for all observations in the sample might be too stringent. This finding is consistent with the theory that since highest and best use changes over both space and time, some areas will experience significant redevelopment while others experience none at all, which is a pattern that would effect the magnitude and significance of the explanatory variables. Additionally, the pseudo R^2 is roughly three times higher in the CPAR probit, suggesting that redevelopment probability is highly dependent on location, and providing further support for the use of a spatially varying probability model.

Redevelopment Probabilities

In Table 1.3, descriptive statistics are provided for the estimated redevelopment probabilities resulting from the standard and CPAR probit models. To compare the results from these two models, only the 5,483 observations where the CPAR probit model successfully converged are included. The mean probability of redevelopment is estimated to be a little over 7% in both models, which is very close to the actual proportion of teardowns observed in our data set (7.38%). However, an analysis of the standard deviation of these estimates indicates these means mask substantial differences between the two models. The standard deviation of CPAR probit (9.10%) is almost twice that of the standard probit (5.92%). This can be attributed to the inherit assumptions of the two models, where the standard model implies fixed coefficients and the CPAR model allows coefficients to differ for each property.

To illustrate the substantial variation in the likelihood of redevelopment over space, a map of the estimated redevelopment probabilities from the CPAR probit is presented in Figure 1.1. The results are consistent with anecdotal evidence and popular press stories of where redevelopment is occurring in Miami: the southern Miami coast which includes the CBD area, the trendy residential and retail district known as Coconut Grove, and continuing towards the border of neighboring Coral Gables.

Hedonic Models

To directly estimate the redevelopment option value within the hedonic framework, the estimated probability of redevelopment for each property is incorporated into a hedonic model. For comparison purposes, the traditional hedonic price model without option value, which specifies price as a function of only structural, locational, and market attributes, is first presented in the first column of Table 1.4. The model reports findings consistent with prior housing studies, where lot size, structural attributes, and proximity to amenities are statistically significant and increase property value, while age and proximity to disamenities are significant and decrease property value. The quarterly time dummies (results not reported) are positive and significant, reflecting a moderate level of appreciation from 1999 to 2002. The adjusted R^2 for the model is 70.48%, which indicates that the base model provides a respectable fit to the data.

Of primary interest to this study, the OLS option value model reports that the coefficient on the estimated redevelopment probability $\hat{\Phi}$ is positive and statistically significant. Option values are non-negative, so the positive sign on the coefficient is important, and the statistical significance of the coefficient provides strong evidence that the redevelopment option is valued by prospective home buyers. Furthermore, the coefficients for *age*, *ln(bldg_sf)*, and *ln(lot_sf)*, as well as for most of the other variables, differ in magnitude from their counterparts in the OLS model without option value. This finding supports the theory of Clapp, Jou & Lee (2012), which asserts that when option value is omitted, the implied attribute prices from the hedonic model (particularly age, interior area, and lot size) are biased.

Biased estimates can also arise from ignoring previous research which finds that teardowns are not randomly selected from the population of housing. Therefore, this non-random selection process could potentially bias the coefficients. Accordingly, a control for selection bias is utilized in this study and is found to be statistically significant in the standard hedonic model. This result implies that controlling for this source of bias is econometrically important when studying real options, and is consistent with the findings of Dye & McMillen (2007) and McMillen (2008).

Despite the statistical significance of the probability variable, adding option value does not appear to substantially increase model fit, as measured by adjusted R^2. The hedonic without option value reports an adjusted R^2 of 70.48%, while the model with option value reports an adjusted R^2 of 70.73%. This is similar to the findings of Clapp & Salavei (2010), where the largest difference in adjusted R^2 between the hedonic without option value and the best fit option model is less than fifty basis points. These findings are most likely attributable to omitted variable bias (where the other coefficients are making up for the omitted option value).

Although the CPAR hedonic model provides robust support to several of the findings from the standard OLS option value model (specifically, the coefficients are still biased when option value is omitted, and the control for selection bias continues to be statistically significant), the model adds several new and important findings beyond that of the OLS model that further contribute to our understanding of the relationship between land values and real options. In the CPAR model, the statistical significance of probability is concentrated in the top 10% of probability (*top_decile_prob*Φ*), which is statistically significant and has the expected positive sign. This interaction term allows the coefficient on probability to shift for properties with an estimated probability above the 90^{th} percentile. The results for this variable indicate a nonlinear option value function consistent with financial call option values.[24] In contrast, the coefficient on probability (*Φ)* is no longer statistically significant for the whole sample. Examining the statistical significance of the probability variable for each of the *n* estimated WLS regressions

[24] Clapp & Salavei (2010) use a similar measure to allow for the nonlinearity in option values.

reveals that probability is found to be statistically significant at the 5% level for 480 observations (8.7% of the final sample). This concentration of option values is consistent with the frequency of actual teardowns in this study (7.8%) and of prior redevelopment studies (3.8% to 17.6%).

The theory of Brueckner (1980) and Wheaton (1982) implies that teardowns are valued only for the underlying land, and therefore the structural coefficients should not significantly contribute to the value of teardown properties. To test this hypothesis, the structural attributes in the CPAR model have been interacted with redevelopment probability (Φ) and one minus this probability ($1-\Phi$) to allow, but not force, the coefficients for the structural characteristics to vary between teardown and non-teardown properties. The results indicate that the structural coefficients of teardown properties (*ln(bldg_sf)*Φ*, *bedroom*Φ*, and *bathroom*Φ*) are statistically insignificant, providing new and strong evidence that teardowns are valued only for the underlying land. The structural coefficients of non-teardown properties (*ln(bldg_sf)*(1-Φ)*, *bedroom*(1-Φ)*, and *bathroom*(1-Φ)*) remain positive and statistically significant, consistent with the findings from prior housing studies. In addition, these results indicate that the interior area coefficient is remarkably different (.464 for non-teardowns) from the standard *ln*(*bldg_sf*) measure used in both the non-option and option OLS models (.651 and .618, respectively), which illustrates the bias produced by this source of model misspecification.

The standard deviation column in the CPAR option model provides evidence that the constant (spatially fixed) coefficient assumption of the standard OLS hedonic models is too stringent. This finding is similar to that of McMillen & Redfearn (2010), where the CPAR model revealed that access to rapid public transportation in Chicago, IL is positively valued in some areas and negatively valued in others, rather than positively valued everywhere as implied by the fixed coefficients from the OLS hedonic model.

In addition to producing spatially varying coefficient estimates individualized for each observation, the spatial model also results in a better fit, as the CPAR model results in a substantially higher R^2 (82.76%) than the OLS option model (70.73%). Overall, this study concludes that spatial models appear to be particularly well-suited for option value studies.

Option Values

Real option theory says that the right without obligation to redevelop a property to its highest and best use is valuable to land owners and therefore should be capitalized into land values. Given that the coefficient on the estimated redevelopment probability is positive and statistically significant in two very different hedonic models, this theory has been validated by the results of this paper.

The final step in the analysis is to quantify the capitalized value of the redevelopment option based on the estimates from the hedonic models. Both Quigg (1993) and Clapp, Salavei & Wong (2010) calculate option value as the percentage difference between property value when the option is in the money and property value when the option has zero value (the property's intrinsic value). Because redevelopment probability is bound by the (0,1) interval, option values are easily computed in a similar way in this study as $exp(\sum \beta X_i) - 1$, where X is the vector of probability variables for the i^{th} observation.

The variation in coefficients across the urban surface allowed by the spatial model highlights two important differences between the option values reported in this study and that of prior literature. First, the CPAR hedonic model provides the ability to compute an individualized option value specifically for each observation in the sample, in addition to computing an overall average for the sample as in prior studies.

Second, the typical assumption of zero demolition costs has been relaxed. This assumption is commonly made because, although option value should be calculated net of all transaction costs, data on demolition costs can be difficult to obtain. More specifically, this study estimates individualized demolition costs for each property using demolition permit data obtained from a neighboring municipality. [25]

Table 1.5 presents descriptive statistics for both the estimated demolition costs and the resulting option values. The estimates indicate an average demolition cost of 4%, with a maximum of 14% and a standard deviation of 2%.[26] In some cases, these demolition costs exceed option value. Therefore, while the results confirm that demolition costs are low on average, there is some evidence that demolition costs can negate the option value for properties that exhibit modest option values.

The option values estimated in the economic intensity model of Table 1.5 utilize the specification of Clapp & Salavei (2010), where economic intensity proxies for the probability of redevelopment. The option values are computed as $exp(\sum \beta X_i) - 1$, where X is the vector of economic intensity variables for the i^{th} observation. This model reports a mean option value of 10%, and is calculated as a comparison to the probability-based models utilized in this study.[27]

[25] Demolition costs are estimated from demolition permits obtained from neighboring Coral Gables, Fl. The natural log of demolition cost is regressed on the natural log of the interior area of the structure to be demolished (both data are included on the permit). The fitted value from this regression (representing variable demolition costs) is multiplied by the interior area of each observation in our sample and the estimated intercept (representing a fixed demolition cost) is then added to this product to arrive at an individualized demolition cost for each house. Because option values are stated in terms of percent of sales price, the estimated demolition cost is converted into a percentage of sales price and then subtracted from option value to calculate the net option value.

[26] A portion of the sample used in Dye & McMillen (2007) report demolition costs, which indicated a median demolition cost of $7,100. The median estimated demolition cost in this study is $5,509.

[27] The hedonic model results are not reported in table form in this paper, but are available upon request.

Results from the probability-based OLS model indicate that option values average 8%, while the CPAR model indicates a mean option value of 9%.[28]

Comparing the results between the economic intensity and OLS option models provides a test of the ability of a proxy variable approach, such as Clapp & Salavei. (2010) where economic intensity proxies for the probability of redevelopment, to capture option value. The results indicate that this approach results in a very similar mean option value when compared to the probability-based results.

However, it is important to note key differences in the specification of these models, which has important implications on the resulting estimates. The economic intensity approach does not account for the endogeniety of the redevelopment decision, control for selection bias, or use interaction terms for the structural characteristics. Therefore, it is possible that the results from the economic intensity model may be biased and as a result complicates comparisons between the two approaches.

Focusing on the results from the CPAR model, the standard deviation (14%) is roughly 40% greater than that of the standard hedonic model (10%). This finding implies substantial variation in option values across the urban space, which is consistent with the theory that option value should be near zero for some properties (particularly new construction) and near 100% for other properties where redevelopment is practically certain. Furthermore, this finding indicates that a spatial hedonic model may capture more of the underlying variation in option values than can the standard OLS hedonic model.

The estimated option values from the CPAR hedonic model are subsequently plotted using GIS software, and the resulting map is presented in Figure 1.2. As predicted by theory,

[28] Similar to the results of Clapp & Salavei (2010), each model reports a maximum option value in excess of 100%. This occurs eight times in the economic intensity model, and once in the OLS and CPAR option models.

option values exhibit a wide degree of spatial variation and spatial clustering. In this sample, option values appear to be concentrated in the CBD-oriented housing just south of the CBD, the corridor along the southern coast including Coconut Grove and continuing into Coral Gables. Additionally, while the neighborhood located near Melreese golf course (just east of the airport) shows significant option value, the modest redevelopment probabilities estimated for the northeastern coast area does not translate into substantial option values (although there are a few exceptions). Similarly, while parts of central Miami indicate moderate rates of redevelopment probability in Figure 1.1, these probabilities do not translate directly into equivalent option values in Figure 1.2. Thus, it appears that although the quantifiable characteristics of a property indicate that it might be a potential candidate for redevelopment, the property's unfavorable location may place little to no value on this probability.

Collectively, the results in this section provide new evidence of the true complexity of the urban spatial structure, where location plays a pivotal role in both land values and the option values that are capitalized therein.

Conclusion

This study can be considered as a linkage between the empirical real option literature and the teardown literature. Clapp & Salavei (2010) use an economic intensity measure as a proxy of the redevelopment decision and to estimate the option value. The redevelopment literature models the redevelopment decision within a probability context to explore issues related to the valuation of land and the determinants of redevelopment. By joining the literatures and explicitly modeling the redevelopment decision within the real option framework, the complexity of the investment decision, specifically in this case the redevelopment decision, can be addressed. The probability-based measure also allows for an econometric strategy which treats the redevelopment decision as endogenous and also addresses issues related to selection bias. The primary contribution of the of this study is a better understanding of the relationship between real options and urban land values, as well as providing insights into the spatial variation of the magnitude of real option values.

The results also provide support for theories related to the urban spatial growth and the valuation of land. Brueckner (1980) and Wheaton (1982) in their studies of urban spatial growth imply that properties purchased for redevelopment can be used to estimate the value of vacant urban land. This theory has made possible urban land value studies where the number of vacant lots is limited (see Rosenthal & Helsley 1994; and Munneke 1996). Simply stated, the economic value of the improvements on a parcel purchased for redevelopment should be zero. Within the model presented in this paper, the price impact of a property's improvements was allowed to vary between teardown and non-teardown properties. Results from the study are unable to reject the null hypothesis that the coefficient on the structural attributes where equal to zero for teardown properties. The structural attributes for non-teardown properties however, remained statistically significant. Therefore, the study provides new and strong evidence that housing purchased for redevelopment is valued only for the underlying land. The recognition of this theory also had an impact on the estimation of the price equation coefficients and the value of the real options. In particular, the interior area coefficient decreased substantially for both teardowns and non-teardowns in the spatial hedonic model relative to the non-option and option OLS models.

In this study, the spatial concentration of real estate decisions is explicitly incorporated into the modeling of the redevelopment decision and the price estimates using a variant of locally weighted regression. This type of modeling allows the coefficients to vary over space and provides probability and option values individualized for each observation, which is appropriate given the spatial distribution of redevelopment and the pivotal role that location plays in option values. The results from the spatial models confirm substantial spatial variation in redevelopment probabilities and option values, and reveal the true complexity of the urban spatial structure. Specifically, the results confirm that redevelopment occurs in spatial clusters near locational amenities and other redeveloped properties rather than being evenly distributed throughout the urban space or occurring as a random phenomenon with no observable pattern. This is an important contribution, because although theory provides general guidance regarding how these option values should vary with a specific property attribute, it was unknown how option values would vary spatially where numerous property, market, and locational attributes interact in potentially complex and competing ways. Results from the study strongly suggest that among these attributes, location appears to be the dominant factor in regards to real option values embedded within urban land values.

The option values reported in this study differ from that of prior studies because the spatial hedonic model allows individualized option values to be estimated for each property and the typical assumption of zero demolition costs has been relaxed. This study finds that while demolition costs are very low, there is evidence that demolition costs can offset option value when option values are modest. Net of these estimated demolition costs, the estimated redevelopment option values in this study are found to range approximately from 0% to 100% of the sales price, with an average value of approximately 9%.

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Table 1.1: Variable Definitions, Descriptive Statistics, and Difference in Means Test

* The t-values (absolute values) reported in the last column are based up the results of a variance equality test between the two groups. Most variances were found to be unequal.

		Non-Teardowns		Teardowns		Difference
Variables	Variable Definitions	Mean	Std Dev	Mean	Std Dev	T-value*
Observations	Total sample contains 5,505 single family residential sales transactions	5,098		407		
General characteristics						
Sales_price	Sales price of the house	$184,841	$210,522	$198,746	$186,823	1.29
Lot_sf	Lot size in square feet	7,205	3,179.7	8,205	4,303.6	4.58
Bldg_sf	Interior square feet	1,692	782.3	1,718	958.9	0.54
Bedrooms	Number of bedrooms	2.71	0.8	2.64	0.9	1.36
Bathrooms	Number of bathrooms (half bath = .5)	1.67	0.9	1.66	1.0	0.32
Floors>1	Number of floors (or levels) > 1 (calculation: floors - 1)	0.09	0.3	0.11	0.3	1.09
Age	Age of the house in years (calculation: sales year - year built)	52.8	15.3	55.8	14.4	3.75
Age99	Age of the house in 1999 (calculation: 1999 - year built)	51.7	15.2	55.0	13.3	4.77
Locational measures						
Dist_coast	Distance from the coastline (in miles)	1.03	0.7	0.80	0.6	7.33
Dist_CBD	Distance from the central business district (in miles)	3.90	1.5	3.73	1.3	2.39
Dist_MIA	Distance from Miami International Airport (in miles)	3.54	1.4	3.81	1.5	3.62
Near_golf	1 if located within .5 miles of a golf course, 0 otherwise	0.03	0.2	0.08	0.3	3.16
Hotel_district	1 if located in the hotel & resort district, 0 otherwise	0.01	0.1	0.02	0.1	2.23
Coconut_Grove	1 if located within Coconut Grove, 0 otherwise. This is a trendy residential & retail area situated along the southern Miami coast.	0.09	0.3	0.18	0.4	4.97
Northeast	1 if located north of interstate I-195 and east of interstate I-95 (except for properties within .5 miles of the coast), 0 otherwise. This is a low income area close to several disamenities.	0.05	0.2	0.07	0.2	1.62

Table 1.1: (continued)

Variables	Variable Definitions	Non-Teardowns Mean	Non-Teardowns Std Dev	Teardowns Mean	Teardowns Std Dev	Difference T-value*
Relative neighborhood measures						
Relative_age	*Age* divided by average age of homes within .75 miles	0.99	0.3	1.06	0.3	5.19
Relative_bldg	*Bldg_sf* divided by average *bldg_sf* of homes within .75 miles and built after 1990	0.71	0.3	0.66	0.3	3.57
Relative_lot	*Lot_sf* divided by average *lot_sf* of homes within .75 miles and built after 1990	1.04	0.4	1.08	0.5	1.51
Intensity measures						
Econ_int	Economic intensity: assessed value of building divided by assessed value of land during the year of sale	1.42	1.1	1.14	0.9	5.89
Lowest_econ_int	1 if *econ_int* is in the lower 10th percentile, 0 otherwise	0.09	0.3	0.25	0.4	7.55
Phy_int	Physical intensity: *bldg_sf* divided by *lot_sf*	0.24	0.1	0.22	0.1	5.67
Lowest_phy_int	1 if *phy_int* is in the lower 10th percentile, 0 otherwise	0.09	0.3	0.20	0.4	5.31
Ptear	Percent teardown: number of teardowns within .75 miles that occurred during the 3 years prior to the sale of the subject, divided by all sales within .75 miles of the subject	1.66	2.1	2.26	2.5	4.69

Table 1.2: Probit Model Results

Results from the standard probit are reported for the total sample of 5,505 observations, while results from the CPAR probit are reported for the 5,483 observations where the CPAR probit model successfully converged.

	Standard Probit			CPAR Probit			
Variable	Estimate	Std Error	P-value	Mean	Std Dev	F-Test	P-Value
Intercept	-4.261	1.796	0.018	-7.626	22.240	1.280	0.155
ln(lot_sf)	0.334	0.439	0.447	0.987	3.192	1.269	0.161
ln(bldg_sf)	0.015	0.395	0.970	0.335	2.362	1.268	0.159
Bedrooms	-0.040	0.046	0.385	-0.075	0.277	2.304	0.000
Bathrooms	0.010	0.054	0.859	-0.080	0.202	1.064	0.372
Floors>1	0.053	0.101	0.600	-0.001	0.242	1.355	0.162
Age99	0.017	0.008	0.039	0.010	0.144	1.743	0.023
Dist_coast	-0.129	0.136	0.342	-0.958	7.047	1.310	0.180
Dist_CBD	-0.079	0.048	0.096	-0.472	3.040	1.705	0.034
*CBD*Coast*	0.030	0.029	0.294	0.141	1.263	1.537	0.098
Dist_MIA	0.027	0.043	0.541	-0.874	3.119	0.976	0.492
Near_golf	0.489	0.167	0.004	0.157	0.357	6.385	0.005
Hotel_district	0.583	0.254	0.022	0.031	0.141	0.298	0.655
Coconut_Grove	0.474	0.125	0.000	0.082	0.403	2.950	0.047
Northeast	0.219	0.127	0.083	0.067	0.244	1.303	0.261
Relative_age99	-0.258	0.157	0.099	-0.730	1.392	1.259	0.196
Relatative_bldg	-0.002	0.336	0.995	0.139	2.788	0.971	0.504
*Relative_age99*relative_bldg*	0.226	0.297	0.447	-0.043	2.123	2.070	0.002
Relative_lot	-0.789	0.453	0.082	-0.051	7.711	1.875	0.006
ln(econ_int)	-0.121	0.057	0.034	-0.299	0.402	2.427	0.000
Lowest_econ_int	0.342	0.100	0.001	0.167	0.384	2.363	0.000
Phy_int	-0.929	1.459	0.524	-0.597	9.076	1.424	0.075
Lowest_phy_int	0.217	0.114	0.056	0.162	0.449	2.052	0.001
Ptear	0.052	0.014	0.000	0.046	0.112	0.896	0.615
Municipality dummies	NA			Yes			
N	5,505			5,483			
Pseudo R^2	11.43%			32.26%			

Table 1.3: Estimated Redevelopment Probabilities

This table compares the probability estimates for the 5,483 observations where the CPAR probit model successfully converged.

	Standard Probit	CPAR Probit
Mean	7.40%	7.25%
Std Dev	5.92%	9.10%
Min	0.32%	0.01%
Max	71.07%	99.43%
N	5,483	5,483

Table 1.4: Hedonic Model Results

Results from the standard value model are reported for the total sample of 5,505 observations, while results from the CPAR model are reported for the 5,483 observations where the CPAR probit model successfully converged. The standard errors in model 2 have been corrected for heteroskedasticity (note that the F-test in model 3 does not utilize standard errors). Models 2 & 3 utilize interactions between the primary structural attributes and estimated redevelopment probability (Φ) and one minus the probability (1-Φ), which allows the structural coefficients to differ for properties with high and low probability of redevelopment, respectively.

	OLS (No Option)			OLS Option Model			CPAR Option Model			
Variable	Estimate	Std Error	P-value	Estimate	Corrected Std Error	Robust P-Value	Mean Estimate	Std Dev	F-Test	P-Value
Intercept	4.015	0.158	<.0001	3.884	0.187	<.0001	6.202	3.087	16.632	<.0001
ln(lot_sf)	0.367	0.016	<.0001	0.419	0.028	<.0001	0.205	0.134	10.364	<.0001
ln(bldg_sf)	0.651	0.020	<.0001	0.618	0.025	<.0001				
Bedrooms	-0.062	0.008	<.0001	-0.066	0.008	<.0001				
Bathrooms	0.081	0.009	<.0001	0.081	0.010	<.0001				
Floors>1	0.187	0.017	<.0001	0.192	0.019	<.0001	0.102	0.074	2.312	<.0001
Age	-0.003	0.000	<.0001	-0.002	0.000	<.0001	-0.001	0.001	1.781	0.005
Dist_coast	-0.283	0.021	<.0001	-0.300	0.023	<.0001	-0.426	2.197	2.962	<.0001
Dist_CBD	-0.026	0.007	0.001	-0.036	0.009	<.0001	-0.016	0.450	8.203	<.0001
*CBD*Coast*	0.044	0.004	<.0001	0.046	0.005	<.0001	0.031	0.416	2.251	0.007
Dist_MIA	0.022	0.005	<.0001	0.027	0.005	<.0001	0.106	0.564	10.203	<.0001
Near_golf	0.045	0.028	0.107	0.122	0.034	<.0001	0.021	0.090	0.170	0.935
Hotel_district	0.101	0.055	0.068	0.114	0.060	0.056	0.021	0.097	2.359	0.099
Coconut_Grove	0.363	0.020	<.0001	0.412	0.034	<.0001	-0.015	0.162	19.501	<.0001
Northeast	-0.501	0.022	<.0001	-0.474	0.022	<.0001	-0.018	0.083	9.303	<.0001
Φ (teardown probability)				1.240	0.425	0.004	0.375	5.440	0.421	0.993
Selection				-1.528	0.440	0.001	0.184	0.774	1.478	0.073
*Top_decile_prob*Φ*							0.225	1.659	1.447	0.017
*ln(bldg_sf)*Φ*							0.344	0.788	0.745	0.802
ln(bldg_sf)(1-Φ)*							0.464	0.160	14.076	<.0001
*Bedroom*Φ*							0.003	0.715	1.073	0.367
Bedroom(1-Φ)*							-0.016	0.033	0.780	0.797
*Bathroom*Φ*							0.049	0.668	1.265	0.180
Bathroom(1-Φ)*							0.038	0.041	1.734	0.008
Time dummies (qtr)	Yes			Yes			Yes			
Municipality dummies	NA			NA			Yes			
N	5,505			5,505			5,483			
Adj R^2	70.48%			70.73%			82.76%			

Table 1.5: Option Value Estimates

Option values reported in this table are net of estimated demolition costs.

	Estimated Demolition Costs	Economic Intensity Model Option Value > 0	OLS Model Option Value > 0	CPAR Model Option Value > 0
N	5,505	1,820	4,246	570
Mean	4%	10%	8%	9%
Std Dev	2%	16%	10%	14%
Min	0.18%	0.03%	0.01%	0.01%
Max	14%	351%	140%	136%

Figure 1.1: Redevelopment Probabilities

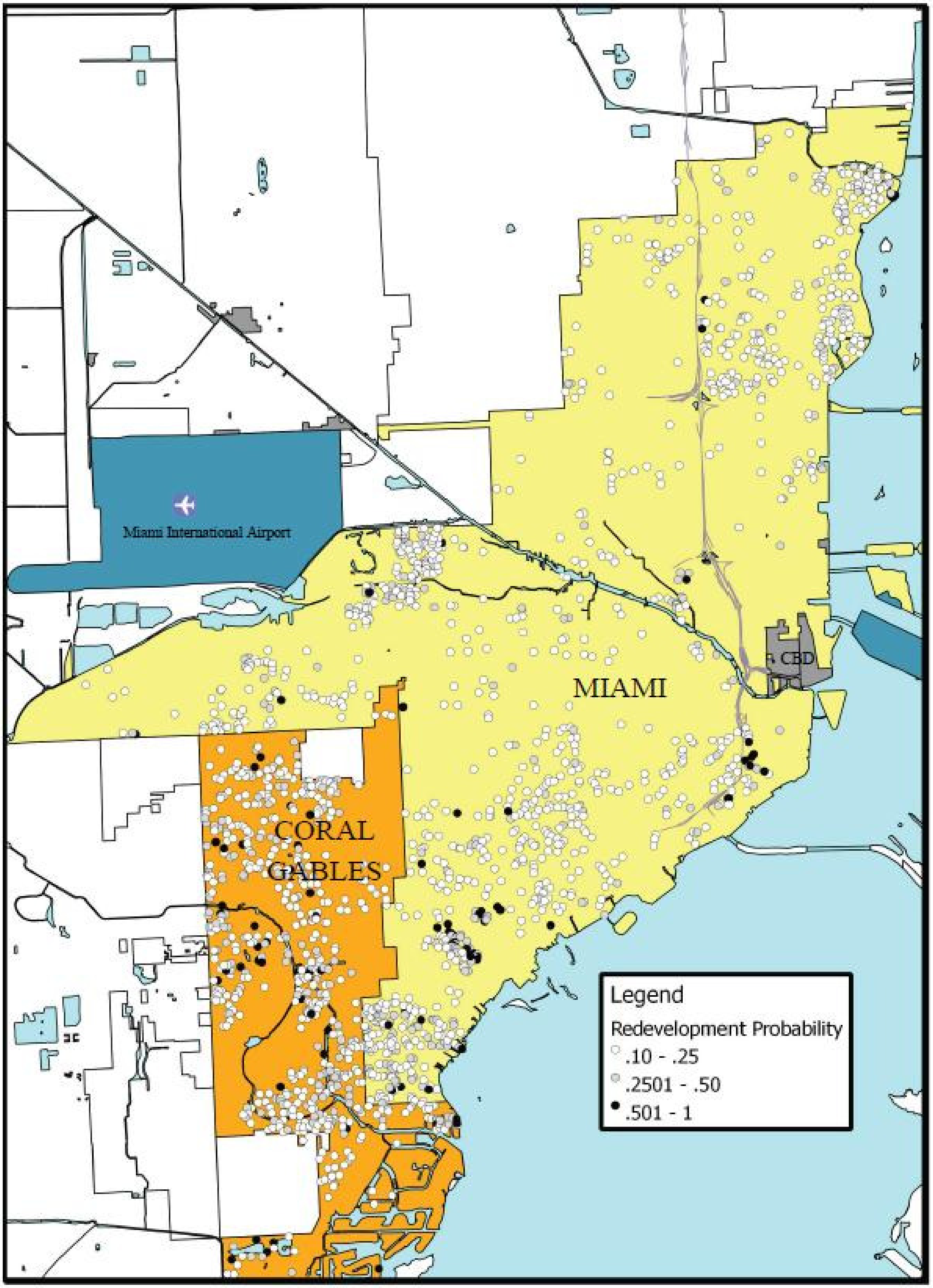
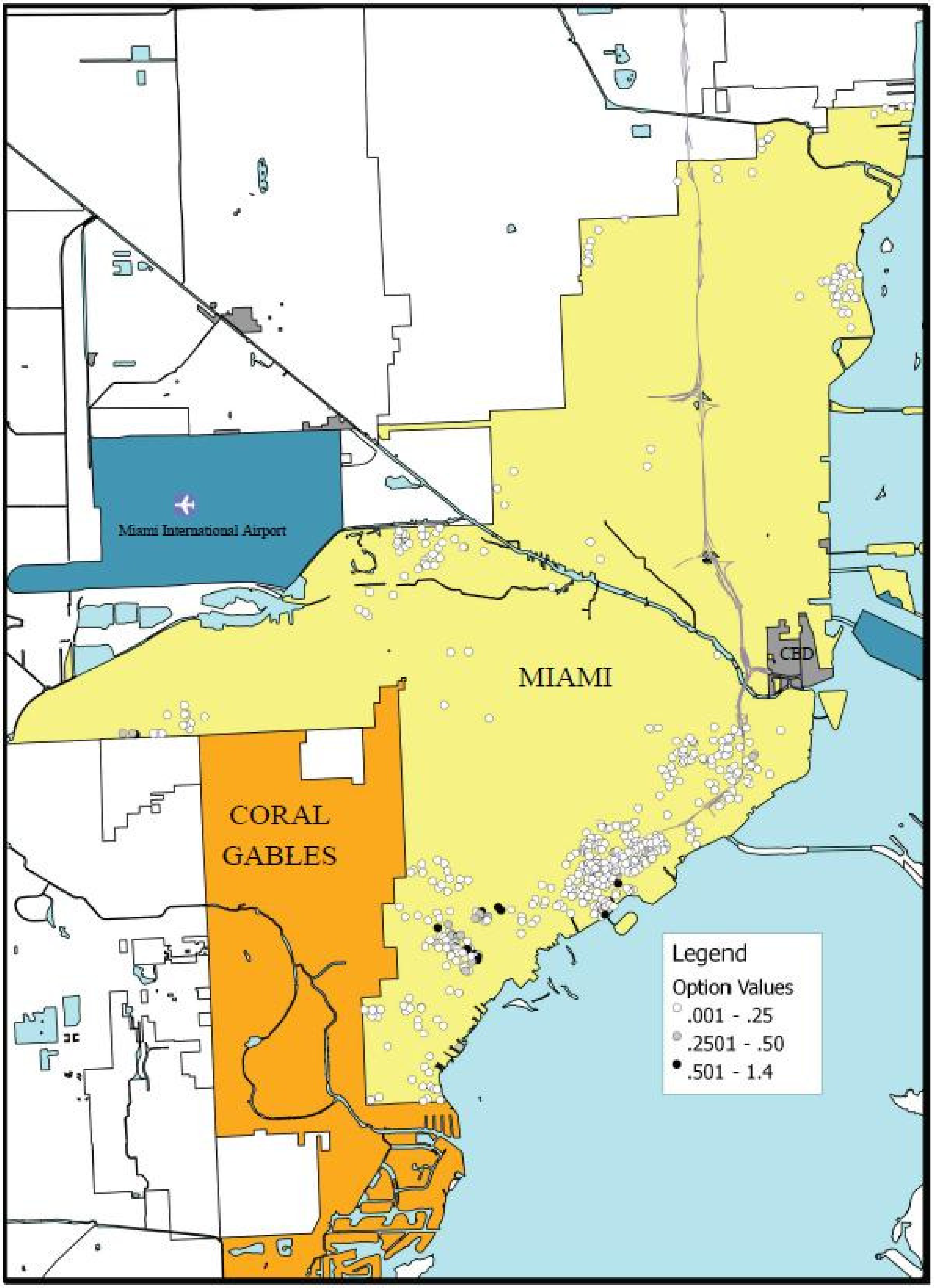


Figure 1.2: Option Values



CHAPTER 2

GENTRIFICATION AND THE DECISION TO RENOVATE OR TEARDOWN

Abstract

The housing location decision for upper-income consumers is largely determined by two dynamic yet opposing forces: minimized commuting costs made possible by CBD-oriented homes versus maximized housing service consumption made possible by newer and larger suburban homes. When gentrification occurs, both of these forces are aligned to pull upper-income consumers in the same direction towards the CBD. Although renovations and teardowns have been studied in the gentrification literature as separate phenomena, redevelopment is actually a mutually exclusive choice between the two processes. Therefore, by examining the determinants of the decision to renovate or teardown within a more comprehensive context, this paper provides a better understanding of the gentrification process. Additionally, the paper tests theories regarding the relative implicit market prices of the structural attributes of renovation and teardown properties. Most notably, results from the study indicate that properties purchased for major renovations are equivalent to teardown sales, where the property is valued only for the underlying land.

Introduction

The literature on urban spatial income patterns has established that the housing location decision for upper-income households is primarily a tradeoff between two dynamic yet opposing forces: minimized commuting costs made possible by living near the CBD versus maximized housing service consumption made possible by newer and larger suburban homes. Although there has been some debate in the literature regarding which force is stronger[29], studies continue to focus on commuting costs and housing demand to explain why people of different incomes live where they do. There is, however, a special case when these opposing forces are aligned to pull upper-income households in the same direction towards the CBD. This occurs through the process of gentrification, which is typically defined as the upper-income resettlement and revitalization of lower-income neighborhoods.

The terms “resettlement” and “revitalization” within this definition emphasize that gentrification is one of many phases in the long-term housing life cycle.[30] According to filtering models[31], this life cycle begins with some exogenous factor that generates construction of new housing. The passage of time causes the quality of this housing to decline, and so the willingness to purchase the house by any income group will likewise decline. Since housing (and therefore housing quality) is considered to be a normal good, the decline in the bids of high-income

[29] Alonso (1964), Mills (1967), and Muth (1969) assume that housing demand is more income-elastic than commuting costs to explain the observed location pattern of upper-income households in the suburbs. Wheaton (1977) finds the elasticities are similar, and LeRoy & Sonstelie (1983) argue that the elasticities depend on which transportation modes are available in the CBD versus the suburbs. Glaeser, Kahn, and Rappaport (2008) argue that the housing-based force is far weaker than the time-cost force and suggests that the poor live in urban areas due to access to public transportation. Due to the location patterns seen in U.S. versus those in foreign cities, other studies have explored explanations outside the basic urban model. For example, Kern (1981) presents evidence that “non-work opportunities”, such as cultural, social, and entertainment activities, pull upper-income residents back to the city. Similarly, Brueckner, Thisse, and Zenou (1999) argue that topographical and historical amenities in the city center may attract the rich more strongly than the poor. Still others suggest that fiscal amenities matter. For example, Nechyba &Walsh (2004) argue that homogeneous suburban communities allow high-income households to escape redistributive central-city taxation while improving the quality of public goods.

[30] Rosenthal (2007) provides evidence that a complete cycle can last up to 100 years.

[31] See for example Smith (1972), Sweeney (1974), Weicher & Thibodeau (1988), Rosenthal (2008), and Brueckner & Rosenthal (2009).

households will be greater than that of low-income households, which causes this housing to filter down to a lower income group. In turn, these families vacate housing of lower quality, and so on. This process repeats itself until, at the lowest end of the quality distribution, the housing has reached the end of its economic useful life. This is particularly the case in many downtown areas, given that cities typically grow from the center outwards and therefore the CBD presumably contains some of the oldest and most depreciated housing.[32] With no one left for this housing to filter down to, it is often abandoned and drops out of the housing stock altogether.[33] However, through the process of gentrification, this low quality housing is redeveloped into a new or like-new structure, thereby restarting the life cycle once more.

Accordingly, redevelopment is considered to be a necessary condition for gentrification.[34] As used in this context, redevelopment is a generic term because the existing structure can be redeveloped either in part or in whole. When redevelopment in part occurs through renovations, the structure itself remains but the interior and or exterior is substantially remodeled and or expanded.[35] When redevelopment in whole occurs through teardowns, the existing structure is completely demolished and a brand new structure is constructed in its place.

Theoretically, redevelopment occurs for two primary reasons. First, because homes consist of a bundle of both malleable and nonmalleable characteristics, prospective buyers may find that the desired combination of structure and location is not available on the market. Therefore, a

[32] Consistent with this presumption, Glaser, Kahn, & Rappaport (2008) find that approximately 20% of the urban population lived in poverty, versus 7.5% of the suburban population.
[33] If maintenance and demolition costs are costly, it may be optimal for the owner to abandon the property (Arnott, Davidson, & Pines, 1983).
[34] However, it is not a sufficient condition, because some redevelopment occurs through "incumbent upgrading", where existing residents redevelop their property. Since there is no socioeconomic change in the property owner, then incumbent upgrading, by definition, does not lead to gentrification (Helms, 2003). Furthermore, redevelopment has been documented in prior studies (Helms, 2003; McMillen, 2004; Dye & McMillen, 2007; Clapp & Salavei, 2010) to also occur in upper-income neighborhoods, which also precludes gentrification.
[35] It is important to note that renovations (which are also known as rehabilitations) are not synonymous with repairs, where only malfunctioning or depreciated structural attributes are restored.

buyer will purchase the latter and subsequently contract for the former by renovating the property. Second, if the value of a property (less demolition costs) is equal to or less than the cost of vacant land, then it is rational to teardown the structure and construct a new one in its place.[36]

Furthermore, the redevelopment decision may also be influenced by idiosyncratic household preferences, where some upper-income households may prefer the larger-sized houses (with master suites, expansive kitchens, home theaters, and other space-consuming features) and modern architecture typically associated with teardowns, while other consumers with similar household income are more interested in the vintage of historic buildings and prefer renovated homes.

Although homeowners clearly face a mutually exclusive decision to either renovate or teardown the existing structure, most of the gentrification literature has examined these processes as separate phenomena. Furthermore, each of these studies utilize different samples from different municipalities at different points in time. Therefore, a direct comparison of the relationship between renovations and teardowns has not yet been made within an academic study. This discontinuity in the literature is most likely the result of non-trivial difficulties in obtaining and merging the necessary data on building permits, demolition permits, sales transactions, and housing characteristics.

Therefore, the goal of this paper to provide a direct comparison of the decision to renovate or teardown single-family residential properties by using a sample of renovations and teardowns from the same municipality (Miami, Fl) during a period of relatively stable economic conditions (1999-2002). To overcome the previously mentioned data difficulties, this study employs a novel approach to identify renovations and teardowns from a set of property tax roll files that are

[36] Brueckner (1980) and Wheaton (1982) established this theory. For empirical tests of the theory, see Rosenthal and Helsley (1994); Munneke (1994); Dye & McMillen (2007); McMillen & O'Sullivan (2012), and Munneke & Womack (2011).

commonly available to the general public. The study then proceeds by analyzing the redevelopment decision within a polychotomous choice framework. This approach results in an unbiased and more efficient estimator compared to the dichotomous models used by prior studies, since the latter ignore important information in the data about the other choices.[37]Additionally, as will be discussed shortly, the study further extends the gentrification literature by examining the relative value of the structural attributes based on redevelopment status.

Results from the polychotomous choice model reveal several interesting differences, but also similarities, in regards to the homeowner's choice of the specific redevelopment method. The primary difference between renovations and teardowns is that the level of housing service provided by the existing structure is important to renovations, but not to teardowns. The primary similarities are that the likelihood of both renovations and teardowns increase with proximity to amenities and decrease with proximity to disamenities. Furthermore, as a new test of the optimal teardown rule of Brueckner (1980) and Wheaton (1982), this study constructs a proxy variable for this rule as the ratio of a property's lot value to total value. As this measure approaches 100%, the structure approaches total economic insignificance, which would (ceteris paribus) make the property an ideal candidate for redevelopment. The results indicate that this proxy variable offers substantial explanatory power not only in the teardown model, but in the renovation model as well, which provides new support of the theory. Moreover, the study finds that changes in demographic variables, which may capture idiosyncratic household preferences

[37] Prior redevelopment studies which utilize polychotomous choice models are (Shear, 1983), which analyze the decision to move and renovate, move and not renovate, stay and renovate, or stay and do nothing, and (Pollakowski, 1988) which studies the decision to hire contract labor, not hire contract labor ("do-it yourself" renovations), or do nothing.

regarding redevelopment, offer more explanatory power than the levels of those variables in models of both the renovation and teardown decisions.

In addition to analyzing how the determinants to renovate differ from teardowns, the study also provides an empirical test of the relative implicit value of the structural attributes among renovations, teardowns, and properties that are not redeveloped. Dye & McMillan (2007) suggest that when a home is sold prior to a major renovation, the structural characteristics are likely to have less influence on the sales price than when the home is not renovated subsequent to the sale. More specifically, in the extreme case some homes may be so extensively remodeled that they are effectively new, and therefore the sale prior to renovation plausibly might be little different from a teardown sale.

Accordingly, this study estimates conditional price equations for teardowns, renovations, and non-redeveloped properties to further examine this subject. Results from these hedonic models provide two important findings. First, the structural attributes for properties purchased for renovations are found to be less valuable than non-redeveloped properties. Second, properties purchased for major renovations, which are redeveloped to the point that the structure is effectively brand new, are found to be equivalent to teardown sales, where the property is valued only for the underlying land.

The remainder of this paper proceeds as follows. The next section provides a review of the prior redevelopment literature. A simple model of the redevelopment decision is presented in section three. The specification of the conditional price equations is presented in section four. The data are detailed in section five. An analysis of the study's results is presented in section six. The last section offers concluding thoughts.

Literature Review

The earliest redevelopment studies analyze data obtained from the U.S. Census Bureau's *Survey of Residential Alterations and Repairs* (SORAR) or the decennial census.[38] Subsequently, the creation of the more detailed *American Housing Survey* (AHS) by the U.S. Department of Housing and Urban Development (HUD) in 1973 led to a substantial increase in the number of renovation studies. Only since the 1980s have individual property-level data been examined in renovation studies. In contrast, all empirical teardown studies have utilized property-level datasets. Because the redevelopment literature has focused separately on renovations and teardowns, this literature review proceeds in the same manner.

Renovation Literature

Mendelsohn (1977) utilizes SORAR data from 1971 to 1972 to conduct the first empirical examination of renovations. Although the study is national in scope, the data is lacking many of the explanatory variables typically found in more recent renovation studies. Nevertheless, it is the first study to present empirical evidence that income, owner age, and race are important determinants in the renovation decision.

Using data from the 1970 census, Melchert & Naroff (1980) provides the first detailed census block-level renovation analysis. The study is the first empirical analysis to provide evidence that changes in the number of family members and neighborhood quality may be more important than their static counterparts in explaining renovations.

Subsequent to these studies, the literature shifted to using the AHS data, which contains more detailed information regarding renovation activity. Shear (1983), uses AHS data from 1974 to 1977 to argue that since homeowners face significant transaction costs when they move, it is

[38] SORAR data is available back to 1962. However, the Census Bureau discontinued the survey in 2007.

unlikely that renovation decisions can be adequately explained without relating it to the move decision. Accordingly, the study examines the decision to move, to stay and renovate, or to do nothing within a multinomial logit model. Montgomery (1992) uses the 1985 AHS data to also examine the move or renovate decision by providing a theoretical model in which homeowners simultaneously choose the level of housing stock to hold and the means by which they adjust their current holdings of housing stock (by moving or renovating) in order to maximize utility. Additionally, the study provides evidence that properties undergoing major renovations (classified as such by the type of renovation projects undertaken, as provided in the AHS data) are found to exhibit selection bias, which suggests these properties are not randomly selected from the housing population at large.

Similar in spirit to Melchert & Naroff (1980), Baker & Kaul (2002) uses changes in the AHS surveys from 1993 to 1997 to test the theory that renovation projects are undertaken to modify the home to the evolving composition of the household. Specifically, the authors use several different variables to show that additions in the number of household members increase the likelihood of renovations, whereas subtractions decrease the likelihood.

Plaut & Plaut (2010) uses the 2005 AHS survey to extend the move or renovate analysis by focusing only on major renovations (e.g.: adding a room) as opposed to other minor forms of renovation (e.g.: remodeling a kitchen). The authors find that households that neither move nor renovate appear to be on average those with lower socioeconomic status, while households that both move and renovate have higher incomes, are younger, and have somewhat larger households. Households which move without renovating, or renovate without moving, on average tend to fall in between the higher and lower socioeconomic groups.

Somewhat surprisingly, relatively few of the prior renovation studies have utilized property level transaction data. Mayer (1981), the first of such studies, provides a theoretical housing renovation model and focuses on the structural and locational determinants of rental housing renovations in Berkley, California from 1973 to 1975. Results indicate that older, smaller, owner-occupied units that are structurally sound and had not been recently renovated are the most likely to be renovated. However, the effects of many of the neighborhood characteristics are statistically insignificant.

Helms (2003) utilizes a theoretical model based on the that of Mayer (1981) and analyzes a detailed parcel-level dataset of all residential renovation activity in Chicago, IL from 1995 to 2000. The paper establishes that property's structural and locational attributes, as well as the demographic characteristics of the surrounding neighborhood all influence the likelihood of renovations. Particularly, older, lower-density houses in older, moderate-density neighborhoods with high median housing value are most likely to be renovated. Rehabilitation is also more likely in areas where the population is well-educated, but less likely in areas with a high proportion of young adults. Somewhat contrary to theory, high concentrations of singles (which are thought to increase the likelihood of redevelopment since they are often higher-income professionals employed in the CBD) or children (which are thought to decrease the likelihood of redevelopment due to school quality and crime issues often associated with newly gentrifying areas) are found to be insignificant in the renovation decision, whereas renovations are found to be more likely in neighborhoods with a high population of blacks or other minorities and less likely in neighborhoods of high median income levels.

Culp (2010) examines homeowners in Pennsylvania from 2000 to 2005 who moved within the previous five years to analyze the impact of detailed environmental attributes (e.g.: proximity to parks, power lines, scenic views, woods, mature landscaping, etc.) on the likelihood of performing major renovations. The authors construct an environmental index of these detailed measures, which is found to have significant explanatory power in a logit model of the renovate or move decision.

Teardown Literature

In their theoretical studies of urban spatial growth, Brueckner (1980) and Wheaton (1982) conclude that redevelopment will occur when the price of land for new development exceeds the price of land in its current use by the cost of demolition. Because this theory implies that properties purchased for redevelopment can be used to estimate the value of vacant urban land, the theory has made possible urban land value studies where there number of vacant lots is limited.

Rosenthal and Helsley (1994) empirically tests this theory using single-family residential housing in Vancouver, British Columbia in 1987. Assuming that demolition costs are insignificant, the authors provide evidence that the price of a property to be demolished upon sale is equivalent to that of the vacant land. Munneke (1994) extends this research, based on commercial and industrial properties in Chicago, IL from 1987 to 1990. The study finds that the probability of redevelopment increases as the value of a parcel in its redeveloped state increases relative to its value in its current use.

Weber et al. (2006) studies the determinants of tearing down single family residential housing within the context of consumer preferences, neighborhood change, and public policy using transactions in areas of Chicago from 2000 to 2003 that have experienced significant gentrification. The study is similar to the current paper in that it uses data from the GeoLytics

Neighborhood Change Database to test whether changes in demographic variables offer more explanatory power in models of the teardown decision than do the levels of demographic variables. The study concludes that neither the demographic variables nor political jurisdictions have much predictive capacity compared with the building and locational variables. The authors speculate that these findings may be due to insufficient variation in the educational makeup, housing tenure, or income of households in these neighborhoods, or that these social indicators alone are not predictive of taste. The one demographic variable that appeared to have an effect, although inconsistent, was the percent change in the Hispanic population between 1990 and 2000. The authors note that this finding may be associated with the documented displacement of Hispanic residents by white residents through such processes as the conversion of multifamily rental properties to condominiums. In summary, the study concludes that building characteristics, changes in ethnicity, and presence near the residential core of a neighborhood may provide the best leading indicators of future physical change in gentrifying areas.

Dye & McMillen (2007) uses single family residential transactions in Chicago and surrounding suburbs from 1997 to 2003 to examine the determinants of the teardown decision and to value teardown properties. Prime teardown candidates are found to be small, older, homes near public transportation and traditional village centers. After controlling for selection bias, the conditional price equations for teardown properties confirm that structural variables do not provide statistically significant explanatory power. Additionally, the study tests whether teardown status, which is indicated by the procurement of a demolition permit by the homeowner, may be subject to misclassification. Misclassification may occur because obtaining a permit does not automatically imply that a structure is demolished. Furthermore, the authors suggest that some non-teardown properties may be very similar to teardown properties.

Specifically, this may be the case when a home is sold prior to a major renovation, where the structural characteristics are theorized to have less influence on the sales price than when the home is not renovated subsequent to the sale. In the extreme case, some homes are so extensively renovated that they are effectively new, and therefore the sale prior to a major renovation is theorized to be little different from a teardown sale. Results from the study provide evidence of a high probability of misclassification in that some non-teardown properties are similar to teardown properties, whereas there is a low probability of misclassification of non-teardowns as teardowns. Additionally, this technique provides strong support for the predication that the sales prices of teardowns reflect only the value of the land.

McMillen (2008) utilizes data from Chicago from 1995 to 2003 to show how non-sample information can be used to make efficient use of limited data when a group of variables (in this case, the structural characteristics of teardown properties) are expected *a priori* to provide little explanatory power. Results from this technique suggest that a weighted average of the OLS estimates with and without the structural characteristics as explanatory variables can produce an efficient set of land value estimates within small samples.

McMillen & O'Sullivan (2012) presents a theoretical model which implies that the structural characteristics of teardown properties will account for a larger proportion of the sale price the longer the time between the purchase date of the property and the demolition date. If a home is demolished immediately after a sale, the structural characteristics for teardown properties should exhibit the typical effect, where they do not contribute to the sales price. However, if there is a considerable lag between the purchase date and teardown date, then the structural attributes of teardown properties should remain valuable, since the structure still provides a housing service flow until demolition. The authors use teardown data in Chicago from

1997-2008 and a parametric duration model to test the model's theoretical predictions. Results from the study confirm that the coefficients of structural attributes do vary as expected with the estimated hazard rate of demolition, where the value of structural attributes decrease as the probability of teardown increases, and vice versa.

In a related thread of literature, studies have focused on estimating the redevelopment option that is capitalized into land values. According to capitalization theory, because land ownership conveys the right without obligation to redevelop the property (analogous to a financial call option) and because land use decisions involve a high degree of uncertainty and irreversibility, a redevelopment option should therefore be capitalized into improved land values. Accordingly, Clapp & Salavei (2010) uses single family residential transactions from Greenwich, CT from 1994 to 2007 to show that the standard hedonic model can be modified to identify the redevelopment option value as separate from the value of the land and improvements. The authors provide evidence that "economic intensity" (the ratio of assessed value of the building to the assessed value of land) is negatively correlated with the likelihood of redevelopment. Munneke & Womack (2011) use single family residential transactions in Miami, Florida from 1999 to 2002 (the same primary sample as the current paper) to show that the probability of redevelopment can be incorporated within a hedonic model to capture this option value. Furthermore, the study provides new evidence that housing purchased for redevelopment is valued only for the underlying land.[39]

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[39] Several other studies have examined redevelopment from a generic perspective, concentrating neither on renovations nor teardowns. For example, Capozza and Li (1994) analyze the redevelopment decision under uncertainty by extending the general model of McDonald & Siegel (1986) and focusing on the role of variable physical capital. Results from the study show that when intensity of physical capital can be changed and the future is uncertain, reservation rents increase, investment decisions are delayed, conversion time increases, and higher amounts of physical capital are employed. Written at the same time but using different assumptions, Childs et al. (1996) and Williams (1997) reach similar conclusions in regards to repeated redevelopment. While Williams assumes one property use and development over time, Childs et al. allows for a mix of property types and assumes

A Redevelopment Model

Based on the rental housing capital-stock adjustment model of Mayer (1981), Helms (2003) proposes a simple housing renovation model. Although the model examines only renovations, it can be modified into a more general model which allows for redevelopment to occur through either renovations or teardowns. In addition to establishing a theoretical basis for the study, the model provides guidance in selecting explanatory variables for use in the empirical econometric models.

Following the notation of Helms (2003), consider an existing house where k_0 denotes the building's initial (pre-redevelopment) level of housing capital, r_j denotes the level of housing investment made during redevelopment, and $j = (1,2,3$ where 1 = renovation, 2 = teardown, and 3 = non-redeveloped). Because redevelopment occurs through either partial or full demolition of the existing improvements, k_d denotes the level of existing housing capital that is demolished during the redevelopment process. In the renovation case, removal of structural items such as obsolescent roofing, flooring, cabinets, etc. typically implies a small amount of k_d, whereas in the case of teardowns the entire existing structure is demolished implying $k_d = k_0$. Therefore, the post-redevelopment level of housing capital is $k_0 + r_j - k_d$. The post-redevelopment condition of the building is given by the function $c(b, k_0 + r_j - k_d)$, where b is a vector of the existing structural attributes that are unchanged by renovation (such as building age and number of stories; $b = 0$ in the case of teardowns). When redevelopment occurs, $c_r > 0$ (subscript denotes partial derivatives), which is based on the reasonable assumption that redevelopment always improves the condition of the property.

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instantaneous development. Both authors conclude that each subsequent redevelopment is less costly and therefore occurs more frequently and less extensively compared to the single redevelopment case.

The total housing services provided by a building $h\{q(\bar{q},l),c(b, k_0 + r_j - k_d)\}$ are a function of its size q and building condition c. Following Brueckner (1983), building size is expressed as a function of lot size l and the intensity of physical capital $\bar{q}$ employed per unit of land. Expressed in these terms, the model not only provides a link to prior urban spatial studies but also explicitly accounts for the findings of prior empirical research which find that lot size and intensity of the physical capital are critical determinants of the redevelopment decision. Increases in building size and condition increase the level of housing services, so that $h_q > 0$ and $h_c > 0$. Spatial characteristics such as locational and neighborhood attributes are not included in the housing service function under the assumption that houses of the same size and condition should provide the same level of housing service regardless of location. Instead, households are allowed to choose the locational attributes (e.g.: distance to coast and CBD) and neighborhood attributes (e.g.: housing characteristics typical of the neighborhood as well as the demographic characteristics of neighborhood residents[40]) as part of their utility function, which may be written as

$$u\,[h\{q(\bar{q},l),c(b, k_0 + r)\}] \equiv v(q(\bar{q},l),b,r,a,e,\mathrm{t}) \quad , \tag{1}$$

where $r = (r_j - k_d)$ is the net housing capital added, a and e represent vectors of locational and neighborhood characteristics, respectively, and t denotes a numeraire composite consumption good.

Household income is denoted as y and the price of capital by p^k, so that the household's budget constraint is $y = t + p^k r$. Utility maximization over t and r yields the first-order condition

$$v_r/v_t = p^k\,, \tag{2}$$

[40] The notion that households not only pick a neighborhood for the housing characteristics but also the demographic composition is consistent with the sorting literature.

or $u_h h_c c_k / u_t = p^k$, which indicates that the marginal rate of substitution between redevelopment expenditures and consumption must equal the cost of capital. The equation implicitly defines the household's optimal net housing capital investment r^*, which can be written as

$$r^* = r(q(\bar{q},l),b,a,e,p^k) \ . \tag{3}$$

Equation 3 also provides a theoretical basis for the selection of explanatory variables in econometric models of the redevelopment decision. Net housing capital investment is shown to be a function of the intensity of physical capital employed on the land, lot size, structural attributes that do not change with redevelopment, locational attributes, neighborhood attributes, and the cost of capital.

Of central focus of this study, whether and how a household will actually redevelop the structure, depends on the magnitude of r^*. Therefore, letting $\tilde{r}$ denote the actual level of net housing capital added during redevelopment, it follows that

$$\tilde{r} = \begin{cases} r_2^* & \text{if } r_2^* > 0 \text{ and } r_1^* \leq 0 \\ r_1^* & \text{if } r_1^* > 0 \text{ and } r_2^* \leq 0 \\ 0 & \text{otherwise} \end{cases} \ . \tag{4}$$

Equation (4), which does not make use of the actual level of redevelopment but rather distinguishes between the cases in which $\tilde{r} > 0$ and $\tilde{r} = 0$, motivates the use of a polychotomous-choice model. Accordingly, the decision to redevelop can be modeled as

$$I_{si}^* = \omega_s z_{si} + \eta_{si} \qquad s = 1,2,3 \ , \tag{5}$$

where I_i^* is the underlying response variable (an index of the choices made), ω_s is a vector of parameters to be estimated, z_{si} represents the structural, locational, neighborhood, and market characteristics that may determine redevelopment, s = ($1,2,3$ where 1 = renovation, 2 = teardown, 3 = not redeveloped) denotes the current redevelopment status of the property, and

$\eta_{si} \backsim N(0,\sigma^2)$. The condition under which the current redevelopment status s is observed may be written as

$$I = s \;\; iff \;\; I_s^* > Max(I^*_j) \qquad j = 1,2,3 \;\; j \neq s \; . \tag{6}$$

Because prior redevelopment studies model the decision as binary (e.g.: renovate or do nothing), this study contributes to the gentrification literature by recognizing that there are three possible outcomes to the redevelopment decision rather than just two. The advantage of a polychotomous-choice model compared to a binary-choice model performed on two subcategories in limited dependent variable models is that the binary response model ignores information in the data about other choices and as a result produces a biased and less efficient estimator.

There are two primary econometric models appropriate for estimating equation (6), multinomial logit and multinomial probit. The primary consideration in choosing between these models is whether the independence of irrelevant alternatives (IIA) assumption holds.[41] Multinomial logit assumes IIA, while the multinomial probit does not. The current study utilizes multinomial logit because of three primary reasons: Hausman and Small-Hsiao IIA tests indicate that the IIA assumption does hold for the sample used in this study, it has been used in the prior renovate or move literature, and because it simplifies the sample selection correction technique commonly employed in second-stage hedonic models.

Conditional Price Equations

Theory implies that the value of to-be-renovated structures should be lower (due to some combination of physical depreciation, functional obsolescence, and externalities) on average than structures that are not renovated. Furthermore, properties purchased for major renovations, which

[41] The IIA assumption states that the error terms cannot be correlated across alternatives within the model.

are redeveloped to the point that the structure is effectively brand new, are theorized to be equivalent to teardown sales, where the property is valued only for the underlying land. Theory also implies that structural attributes for properties purchased for teardown should not significantly contribute to the value of the property.

This paper tests these three theories by estimating separate price equations, conditional on observed redevelopment status, for renovations, teardowns, and non-redeveloped properties.[42]

The total price equation for a property may be written:

$$P_{si} = \alpha_s + \beta_s x_{si} + v_{si} \qquad s = 1,2,3 , \qquad (7)$$

where P_{si} represents the natural logarithm of the selling price of the i^{th} parcel that is purchased for redevelopment status s, β_s are the estimated parameters for redevelopment status s, x_{si} is a vector of exogenous explanatory variables, and $v_{si} \backsim N(0, \sigma^2)$.

The condition under which the current redevelopment status s is observed may be written as Eq. (6). Within the context of the current study, the price of an individual house can be observed in one of three states of nature: either the house is a renovation ($I_i = 1$), it is a teardown ($I_i = 2$) or it is not redeveloped ($I_i = 3$). From Eq. (6), it follows that

$$I = s \quad iff \quad \omega_s z_s > \epsilon_s^* \qquad (8)$$

where $\varepsilon_s = Max(I^*_j) - \eta_s$. Following Lee (1982, 1983) ε_s is transformed to a standard normal random variable using the J-factor:

$$J_{si}(\varepsilon_s) = \Phi^{-1}(F_s(\varepsilon_s)) , \qquad (9)$$

[42] McMillen & O'Sullivan (2012) points out that true teardown status is difficult to observe precisely when using building permits. However, this concern should be minimized in the current study because renovation status is actually observed in the panel data identification process of redevelopment, rather than relying on permit data in which redevelopment may or may not immediately occur after the permit is issued.

where Φ^{-1} is the inverse of the standard normal distribution function and F_s is the distribution function for the extreme value distribution. Accordingly, the condition stated in (8) may be rewritten as:

$$I = s \quad iff \quad J_s(\omega_s z_s) > J_s(\varepsilon_s) = \epsilon_s^* \,. \tag{10}$$

The conditional expectation of the error term in the total price equation using this condition may be written:

$$E(v_{si}|I = s) = -\sigma_s\rho_s = \frac{\phi(J_s(\omega_s z_z))}{\Phi(J_s(\omega_s z_z))} = -\sigma_s\rho_s = \frac{\phi(J_s(\omega_s z_z))}{F_s(\omega_s z_z))}\,, \tag{11}$$

where σ_s^2 is the variance of v_s and ρ_s is the correlation coefficient between ϵ_s^* and v_s. Note that in evaluating the conditional expectation of the total price equation, the expected value of the disturbance term given land use s may not be equal to zero, even though $E(v_{si}) = 0$. Thus, estimating the total price equation, Eq. (7), over each of the zoning classification samples may lead to biased estimates.

To address this potential problem, the two step procedure of Lee (1982) and Maddala (1983) is utilized, where the inverse Mills ratio is included as an independent variable in the total price equation. More specifically, the conditional expectation of the error term, derived in Eq. (11) is added and subtracted from the total price equation, the resulting price equation may be written:

$$P_{si} = \alpha_s + \beta_s x_{si} - \rho_s\frac{\phi(J_s(\omega_s z_s))}{F_s(\omega_s z_s)} + \left[v_{si} + \rho_s\frac{\phi(J_s(\omega_s z_s))}{F_s(\omega_s z_s)}\right], \tag{12}$$

or more concisely as

$$P_{si} = \alpha_s + \beta_s x_{si} - \rho_s\frac{\phi(J_s)}{F_s} + \tau_{si}\,, \tag{13}$$

where $E(\tau_{si}) = 0$ and the variance of v_{si} is assumed to be equal to 1. The significance of the estimated parameter on the Inverse Mills Ratio, referred to here as the selection term, is a test of possible correlation between ϵ_s^* and v_{si}. The presence of such correlation, commonly referred to as sample selection bias, would be present in this study when unobserved characteristics which influence the redevelopment decision also influence the price of the house.[43]

The total price equation expressed in Eq. (13) can be estimated over each of the s sub-samples once the selection variables are constructed from the maximum likelihood estimates of Eq. (5). However, a further modification is needed for one of the conditional price equations. To test for differential pricing in the structural attributes of major and non-major renovations, the dummy variable Ψ_i (which is equal to one if a major renovation and zero otherwise) is interacted with each of the property structural attributes for properties that undergo major renovations, and (1- Ψ_i) is interacted with each of the property structural attributes for properties that undergo non-major renovations. A major renovation is defined in this study as a renovation in which 45% or more of the pre-renovation structure value has been replaced during the renovation process. This percentage threshold was selected for two primary reasons. First, a grid-search of percentages indicates that this level generated the best model fit. Secondly, the threshold is analogous to the 50% teardown rule imposed by the U.S. Federal Emergency Management Agency (FEMA), which essentially states that if the cost to repair a structure in a FEMA-declared disaster exceeds 50% of the pre-disaster condition, then the structure cannot be renovated but must be torn down.[44]

In the conditional price equation for renovations, the vector x_i is partitioned into x^{nm} representing a vector of the property's non-malleable physical attributes (lot size, location variables, neighborhood variables, etc.) and x^m representing a vector of the property's malleable

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[43] Past redevelopment studies have shown that selection bias can be present in both renovations (Montgomery, 1992) and in teardowns (Dye & McMillen 2007; McMillen 2008).

[44] According to FEMA Guidance No. 4511.61 E, "The FEMA regulation [the 50% rule] is based on the finding that when a facility is so severely damaged by a disaster that, not including code triggered upgrades, the cost to repair the damage exceeds 50% of the cost of a new building, it is often justifiable and reasonable to replace the building."

structural attributes. Therefore, allowing $x_{0i}^{nm} = x_{1i}^{nm} = x_i^{nm}$ and constraining only the parameters β for the non-malleable characteristics to be equivalent for major and non-major renovations yields the following model to be estimated for renovation properties:

$$E(P_i|I=1) = \alpha_0 + \beta x_i^{nm} + \gamma_1[x_{1i}^m(\Psi_i)] + \gamma_0[x_{0i}^m(1-\Psi_i)] - \rho_1 \frac{\phi(J_1)}{F_1} + \tau_{1i}\ . \quad (14)$$

For properties purchased as a teardown, the estimated model can simply be written as

$$E(P_i|I=2) = \alpha_2 + \beta_2 x_{2i} - \rho_2 \frac{\phi(J_2)}{F_2} + \tau_{2i}\ , \quad (15)$$

while the estimated model for properties not purchased for redevelopment can be written as

$$E(P_i|I=3) = \alpha_3 + \beta_3 x_{3i} - \rho_3 \frac{\phi(J_3)}{F_3} + \tau_{3i}\ . \quad (16)$$

Data

This study utilizes 5,496 improved single family residential sales transactions in the City of Miami (Dade County), Florida from 1999 to 2002, of which 592 (11%) are classified as renovations (where the existing structure remains but is substantially improved), 403 (7%) are classified as teardowns (where the existing structure is demolished in anticipation of redevelopment) and 4,501 (82%) are classified as non-redeveloped (where the property has not been redeveloped). Renovations occur much more frequently than do teardowns in the sample, which is most likely due to the fact that in most cases the cost of renovating an existing structure is substantially lower than the costs of demolition and subsequent construction of a new structure.

The time frame of the sample utilized in this paper was specifically chosen for several reasons. First, popular press stories and various academic studies imply that Miami has experienced robust redevelopment activity during this time period. Second, it avoids potentially conflating effects of hurricane-related redevelopment.[45] Third, the time frame allows the study to be conducted within the context of a relatively stable real estate market, avoiding both the excess appreciation in home prices during the mid-2000s and the subsequent collapse in prices during the late-2000s.

The data file was obtained from the office of the Miami-Dade County unified government tax assessor. For each property in the county, the file contains physical characteristics, sales transaction data, as well as tax assessed values. For the renovation and teardown properties, all property characteristics are observed prior to redevelopment.

Data filters applied to obtain the final sample include the following: single-family structure, state and county single-family residential land uses, sale must be a arms-length transaction with a sale amount greater than $50,000, owner must be the feeholder (no land leases), 300 sf minimum interior area, 1,500 sf minimum lot size, structure must contain more than one bedroom and three or more total rooms, structure must be built after 1901, valid sales transaction data must be present, and tax assessed values must be present.

Using the methodology outlined in Munneke & Womack (2011), renovations and teardowns are identified by constructing a panel data set from the real property tax roll files for Miami-Dade County obtained from the Florida Department of Revenue. The file contains property-level measures such as year built, effective year built, interior square footage, lot size, land use, the value of any improvements removed or added during the year (which is based on building permit data obtained by the tax assessor's office), as well as sales transaction data and assessed value data reported on an annual basis. Accordingly, by observing the changing physical attributes of a

[45] The major hurricanes effecting Miami around the sample time period were Hurricane Andrew (Category 4, 1992) and Hurricane Wilma (Category 3, 2005). Hurricane Andrew was particularly destructive, where a significant number of homes across Dade County were damaged or destroyed. Hurricane data was obtained from the NOAA (National Oceanic and Atmospheric Administration).

property over time within a panel data setting, renovations and teardowns can be identified without an exhaustive list of demolition and building permits.[46] Specific details of the renovation and teardown identification procedures are provided in Appendices A and B.

The variables used in the econometric models are defined and summarized in Table 2.1. The variables, which were selected based upon theory and the renovation model presented earlier in the paper, can be categorized into three major groups of variables: property, location, and neighborhood.

The most intuitive determinants of redevelopment are the physical attributes of a property that make redevelopment more or less likely. Specifically, the size of the lot and the size and condition of the structure have been shown to be particularly influential in the redevelopment decision. Larger lots enable larger structures to be built, so the size of the lot in square feet (*lot_sf*) should be positively correlated with both renovations and teardowns. Desirable structural attributes, such as the square footage of the structure's interior area (*Bldg_sf*) and the number of bedrooms and bathrooms (*Bedrooms* and *Bathrooms*, respectively), also increase the value of the existing structure and therefore are expected to be negatively correlated with renovations and teardowns. Conversely, structural attributes that capture depreciation effects or otherwise reduce the value of the structure, such as *Age99* (the age of the structure in 1999), are positively correlated with renovations and teardowns.[47] *Land_intensity*, the ratio of the tax assessed value of the lot to the total tax assessed value of the property (in the year of sale), is a proxy for the optimal teardown rule proposed by Brueckner and Wheaton. As this measure approaches 100%,

[46] When the panel teardown list is compared against the demolition permit file, our teardown list successfully captured 93% of the demolition permits for properties common to both the demolition permit list and the Department of Revenue files during the sample time frame. A review of the permits not identified by our approach indicate idiosyncratic issues were the cause of non-identification rather than systematic differences that could be modeled.

[47] The multinomial logit model does not require that a sale transaction has to occur in order to be included in the model. The only requirement is that redevelopment occurred and that the property attributes are observable prior to redevelopment. Therefore, since there may be no sale year, a benchmark date must be used to compute structure age.

the structure approaches total economic insignificance, which would (*ceteris paribus*) make the property an ideal candidate for redevelopment.[48] Accordingly, theory implies that this should be the primary determinant of teardowns. However, this paper also extends the theory to renovations, where this measure should also have explanatory power given that renovations occur as a means of replacing worn out physical capital. Furthermore, to allow for a nonlinear effect in this important variable, *Lowest_LI* is a dummy variable that is equal to one if a property's *Land_intensity* is in the top decile, and zero otherwise.

Since escalating land values provide a central impetus to redevelopment and urban land values are primarily determined by the parcel's location, then proximity to amenities and disamenities should play a central role in redevelopment decisions. After all, if households are willing to redevelop the structure, they are then free to purchase properties based solely on location and then subsequently redevelop the structure into the desired configuration. Accordingly, several locational variables are used in this study as discussed below.

Prior gentrification studies have theorized that a property's location relative to employment centers, cultural amenities, and natural amenities may be particularly influential in redevelopment decisions. In particular, many buyers redevelop CBD-oriented homes because it resolves the conflict between the competing forces of minimized commuting costs and maximized housing service consumption. Accordingly, the variable *Dist_CBD* is used to measure miles from the central business district. Because the Miami CBD is situated very close to the coastline, which is also an important amenity that needs to be controlled for in the econometric models, the variable *Dist_coast* is calculated as the following spline function: miles from the coast minus one mile if the distance is less than one mile, zero otherwise. This

[48] This ratio is also known as "land leverage", as coined by Bostic et al. (2007).

specification, which is similar to that used in other urban economic studies[49], forces the variable to range in value from negative one (zero miles from the coast) to zero (one mile from the coast), which reduces multicollinearity with *Dist_CBD* and allows the impact of the coast on property values to disappear after a reasonable distance.

The gentrification studies of Kern (1981) and Brueckner et al. (1999) suggest that gentrification occurs due to the desire for proximity to cultural and entertainment amenities. Therefore, this study controls for these amenities within Miami. Specifically, *Cgrove* is a dummy variable that is equal to one if the property is located in Coconut Grove, a trendy cultural, residential, and retail area situated along the southern Miami coast, and zero otherwise. Similarly, proximity to a golf course, (which offers recreational opportunities, scenic views, as well as green-space), is controlled for by the variable *near_golf* , which is equal to 1 if the property is located within a half mile of a golf course, zero otherwise.

Conversely, proximity to a major metropolitan airport is considered to be a disamentiy in gentrification studies due to the noise pollution, air pollution, and traffic that often accompany major airports. Therefore, *Dist_MIA* is specified to equal to one if located within 1.5 miles of Miami International Airport (MIA), zero otherwise, which allows for this disamenity to lose its impact after a reasonable distance.[50]

Consistent with the sorting literature and the theoretical renovation model, the redevelopment decision may also be influenced by household tastes regarding neighborhood demographic attributes such as education, income, population density, and race. Moreover, studies such as Melchert & Naroff (1980), Shear (1983), and Baker & Kaul (2002) show that changes in these demographic variables possess more explanatory power than do the levels.

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[49] See for example Colwell & Munneke (2006). One mile was selected based on the results of a grid search of distances that produced the maximum model fit.

[50] The 1.5 mile distance was also selected based on a grid search.

Accordingly, this study uses demographic data obtained from the GeoLytics Neighborhood Change Database.[51] Specifically, this study utilizes data from the 2000 Census and the percent change from the 1990 Census to 2000 Census.[52]

Prior renovation studies such as Galster (1987) and Weber et al. (2006) have identified educational attainment as the central demographic variable associated with gentrification. Therefore, variables measuring the percent of population in the census tract with at least a bachelors degree in the year 2000 and the percent change in this measure from 1990 to 2000 (*college* and *college%Δ*, respectively) are included. The theorized correlation between education and redevelopment is somewhat ambiguous, as discussed in Weber et al. (2006). On the one hand, education might be positively correlated with teardowns because more educated individuals generally have more wealth and more expensive tastes. On the other hand, education might be negatively correlated with teardowns and positively correlated with renovations because educated individuals are often active in historic preservation movements, may prefer rehabilitated older structures, and may organize to prevent demolitions.

Redevelopment is also thought to be determined to a large extent by the high income and purchasing power necessary for redevelopment. Therefore, areas that already have higher household income, as well as areas experiencing increasing household income (*Medfaminc* and *Medfaminc%Δ*, respectively) should be positively correlated with redevelopment. The study also utilizes information about population levels in 2000 and change in population from 1990 to 2000 (*Population* and *Population%Δ*, respectively) in each census tract as proxies for density, traffic, noise, and other population-related factors that have been theorized to influence redevelopment.

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[51] Because the composition of census tracts may change from census to census, this database recalculates and normalizes census data to the year 2000 census tract.

[52] This study's list of demographic variables, as well as the use of both levels and percent changes in demographic variables, is very similar to Weber et al. (2006). Correlations between the level and percent changes for these variables are quite low.

Race may impact development in ways that go beyond household income and earning power, although the direction of the correlation *a priori* is ambiguous. If upper income households prefer to live in more racially homogeneous neighborhoods, redevelopment will be more likely in areas that are or are becoming less diverse. Conversely, if households value the presence and influence of a diversity of cultures within the neighborhood, redevelopment will be less likely in racially homogeneous neighborhoods. Therefore, the 2000 level and percent change from 1990 to 2000 in the percentage of census tract residents that are Black (*black* and *black%Δ*, respectively) and Hispanic (*Hispanic* and *Hispanic%Δ*, respectively) are included. [53]

Two additional, but non-demographic, neighborhood variables are used in this study. Prior research (e.g. Clapp & Salavei, 2010; Munneke & Womack, 2011) has shown that when a neighborhood begins to experience redevelopment, the process often perpetuates itself. This is consistent with ad hoc reports from developers who indicate that they will invest in redevelopment projects only after the neighborhood begins to redevelop. Therefore, while many developers may prefer to be an "early mover" in redeveloping neighborhoods, they generally avoid being the "first mover". Accordingly, the variables *Nrenn* and *Ntear* (the number of renovations and teardowns, respectively, within .75 miles that occurred during the 3 years prior to the sale of the subject property) are utilized to capture prior neighborhood redevelopment activity.

Descriptive statistics for the sample, as well as the results from the difference in means t-tests, are also reported in Table 2.1. In the analysis of the table results that follows, renovations are compared to non-redeveloped properties, then teardowns are compared to non-redeveloped properties, and finally renovations are compared to teardowns.

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[53] Similar to Weber et al. (2006), this study omits several other demographic variables associated with gentrification that are too strongly correlated with those measuring education, income, race, and household composition.

According to the difference in means t-test, properties purchased for renovation (where the property attributes are observed prior to redevelopment) appear to differ from their non-renovated counterparts in regards to virtually every variable measured in the table. Renovations have higher sales prices ($206k vs. $182k) which can be attributed to the larger lots (8,147 sf vs. 7,080 sf), larger interior areas (1,879 sf vs. 1,667 sf), and slightly greater number of bedrooms and baths. Interestingly, there is no statistical difference in the mean structure age between the groups. Of particular interest to this study, properties targeted for renovations have greater *Land_intensity* (49% vs. 47%), which indicates that land makes up a larger percentage of the total property value.[54] In regards to location, renovated properties are closer to the CBD, closer to the coast, further away from the airport, and are more likely to be located near a golf course on average than non-redeveloped properties. Therefore, in addition to having a larger lot, the renovations appear to have superior location compared to non-redeveloped properties. Furthermore, the table reveals that either the level or the percent change in all of the demographic neighborhood measures are statistically different at the mean, suggesting that these variables may indeed have explanatory power in the redevelopment decision.

When properties purchased for teardowns are compared to non-redeveloped properties, the key finding that emerges is that teardowns have superior lot size and location. This is particular evident given the fact that, despite having an older structure that is likely near the end of its economic life, teardowns have a higher sales price than non-redeveloped properties. For teardowns, lot sizes are larger (8,213 sf vs. 7,080 sf), land accounts for over half of the total property value (mean *Land_intensity* is 53% vs. 47%), and are approximately three times more likely to be in the top decile of *Land_intensity* (25% vs. 9%) than non-redeveloped properties.

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[54] Note that this percentage is substantially greater than the 20% "rule of thumb" allocation sometimes used by tax assessors to decompose total property value into separate land (20%) and building values (80%) for property tax purposes.

Teardowns are also superior in regards to location. Teardowns are located closer to the CBD, closer to the coast, further away from Miami International Airport, and have a larger proportion of observations located in Coconut Grove (a trendy retail and residential area situated along the southern Miami coast) and near golf courses. Thus, while teardowns should have less valuable structures, they have more valuable lots (larger with better location) which culminates in a higher property value on average than non-redeveloped properties. As with renovations, the level or percent change in each of the various neighborhood variables are statistically significant. However, unlike renovations, both *Nrenn* and *Ntear* are statistically different at the means, which indicates that teardowns are located in close proximity to both other teardowns and renovations when compared to the non-teardown properties. This finding will be discussed in more detail in the preceding analysis.

The analysis now focuses on the comparison of renovations with teardowns. According to the table, the difference in renovations and teardowns appears to be concentrated in the value-reducing aspects of the structure and value-increasing aspects of the land. On average, properties purchased for renovations are larger (1,879 sf vs. 1,715 sf), contain more bedrooms and baths, and are roughly 3.5 years younger than properties purchased for teardowns, all of which positively impact the relative value of renovated structures over teardown structures. In regards to land, teardowns have a greater portion of property value comprised by the value of the lot (53% vs. 49%) and have roughly three times the concentration of properties in the top decile of this measure (25% vs. 9%). Few variables outside of the property variables are statistically different at the mean. The only statistically different location variable, *Coconut_Grove*, indicates that approximately twice as many teardowns are located in this popular neighborhood than renovations (18% vs. 10%). In regards to the significantly different neighborhood variables, *Hispanic%Δ* indicates that teardowns occur more often than renovations in census tracts with increasing proportions of Hispanic population,[55] while *Nrenn* and *Ntear* indicate that teardowns occur in closer proximity to areas that have experienced prior renovations and teardowns. The fact that teardowns are associated with greater levels of *Ntear* is expected, but given the relative homogeneity of structures within a neighborhood, the fact that teardowns are associated with greater levels of *Nrenn* is unexpected. Given that these findings are based only on univariate measures, the spatial relationship between renovations and teardowns will be further examined within the multinomial logit model.

Results

Multinomial Logit Models

To empirically model the mutually exclusive decision faced by a homeowner to renovate, teardown, or to not redevelop, the study utilizes a polychotomous choice model. This approach results in an unbiased and more efficient estimator than the dichotomous models used by prior studies, since the latter ignore important information in the data about other choices.

The results from the multinomial logit model are presented in Table 2.2.[56] In the model of the renovation decision, *ln*(*Bldg_sf*) is positive and significant while *ln*(*Lot_sf*) is insignificant,[57] which suggests that, after controlling for *ln*(*Land_intensity*) and *Lowest_LI* (which are proxies for the optimal teardown rule), homes which offer greater opportunities for post-renovated space

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[55] According to the 2000 Census, the city of Miami had a population of approximately 2.2 million and was 57% Hispanic, 20% Black, and 23% White (non-Hispanic).

[56] The logit coefficients represent changes in z-scores, not marginal effects, so therefore the results cannot be compared across models. Therefore, to allow for a comparison of the results, marginal effects are created from the mean level of each variable. Accordingly, the marginal effects can be interpreted as the change in the probability of redevelopment, given a one unit change in the variable beyond its mean and assuming there are no changes in the other variables.

[57] When *ln*(*Land_intensity*) and *Lowest_LI* are omitted from the model, both *ln*(*Lot_sf*) and *ln*(*Bldg_sf*) are positively and negatively statistically significant, respectively.

are more likely to be renovated, whereas the size of the underlying lot is much less important. This is not a surprising result if most renovations do not involve a substantial increase in the floor area, but rather occurs as a means to improve the space already present. The fact that *Bathrooms* is negative and statistically significant implies that many renovation projects may involve adding an additional bathroom to the existing structure. The coefficients on *Age99* and $Age99^2$ have the expected positive and negative signs, respectively, and are both statistically significant. Although theory suggests that *ln*(*Land_intensity*) and *Lowest_LI* should be the primary determinants of teardowns, this study extends the test of the this theory to renovations as well. The results indicate that while *ln*(*Land_intensity*) is positive and significant, *Lowest_LI* is negative and significant, implying that renovations do occur when worn out physical capital needs to be replaced, but when too much capital needs replacement the structure is torndown rather than redeveloped.

In regards to the location variables, only two of the five measures are significant. *Dist_CBD* and *Dist_coast* are both negative and significant, indicating that the probably of renovation increases as the distance from the CBD and coast decreases.

In contrast, either the level or percent change (and sometimes both) of each neighborhood variable are statistically significant. The negative coefficient on *Population%Δ* is consistent with the notion that renovations may occur in lower density areas. Both *ln(MedFamInc)* and *MedFamInc%Δ* are positive and significant, implying that neighborhoods that are already or are becoming more affluent may experience renovations. The results of the educational variables are mixed, in that *College* is negative but *College%Δ* is positive. The results of the racial variables are also mixed, where the levels of *Black* and *Hispanic* are negative and significant, but *Black%Δ is positive and Hispanic%Δ* are statistically insignificant. As expected, the coefficient on *Nrenn* is positive and significant, implying that renovations occur in neighborhoods that have already experienced renovation activity in the recent past. However, the negative coefficient on *Ntear* indicates that the presence of prior teardowns in the neighborhood decreases the probability of renovations. The negative and statistically significant interaction term *Nrenn*Ntear* implies that there is a negative correlation between the number of nearby renovations and teardowns. Collectively, these findings are consistent with the notion that if renovations occur in a neighborhood, it is unlikely that the same neighborhood will also experience teardowns, and vice versa. Therefore, if neighborhoods are homogeneous in regards to most attributes, it should be expected that redeveloping neighborhoods should primarily experience one form of redevelopment or the other, but typically not both at the same time.

In the model of the teardown decision of Table 2.2, theory implies that the proxies for the optimal redevelopment rule, *ln*(*Land_intensity*) and *Lowest_LI*, should be the primary determinants of teardowns. As expected, both variables are positive and significant in the model, with very few other property variables remaining significant, which provides new and robust support for the underlying theory. Interestingly, *ln*(*Lot_sf*) remains positive and significant even after controlling for this rule, which is consistent with the importance of land in the teardown decision. *Age99* also remains positive and significant, implying that depreciation effects may not be perfectly captured in the assessed values.

Consistent with theory, the location variables have substantial explanatory power in teardown decisions. Because households are not constrained by the existing structure, they are free to focus on location. Not surprisingly, four out of the five location variables in the model are significant. *Dist_CBD* and *Dist_coast* are both negative and significant, indicating that the probably of renovation increases as the distance from the CBD and coast decreases.

Additionally, the dummy variables *Cgrove* and *Near_golf* are positive and significant, which implies that properties located in Coconut Grove increase the likelihood of teardowns, as does being located near a golf course.

The neighborhood variables involving population, median family income, and education are very similar to the results from the renovation model. Two notable differences are that the racial demographic variables do not seem to influence the likelihood of teardown (which may explain why most teardown determinant studies have omitted these variables) and that *Nrenn* has a negative effect on teardowns, while *Ntear* has a positive effect. These results are consistent with the findings from the renovation model, where teardowns occur in areas that have experienced prior teardowns, but not in areas of prior renovations.

Given the importance of location to the redevelopment decision, and given that it is likely that some idiosyncratic location and neighborhood attributes may be unobserved or are measured imperfectly, a second model of the redevelopment decision is utilized in this study. The specification of this model is the same as that of Table 2.2, with the addition of thirteen separate neighborhood dummy variables as a further control for the influence of location.[58] Furthermore, because it is possible that the demographic variables may be serving as proxies for location (since many neighborhoods tend to be demographically homogenous), this specification should also help untangle the influence of demographics from their neighborhood proxy effect. The results from the model with fixed effects are presented in Table 2.3.

In the renovation model of Table 2.3, all property variable coefficients retain the same signs and their statistical significance, except for *Age99*, $Age99^2$, and *Lowest_LI* which lose

[58] The neighborhoods are defined by the City of Miami Tax Assessor's Office. The omitted neighborhood in the model is a large coastal-oriented neighborhood in north Miami).

significance. These results are consistent with the homogeneity of structure age within neighborhoods, where most homes in the area are constructed within a few years of each other.

While utilizing neighborhood fixed effects are useful in hedonic models of urban housing values, many times their inclusion can capture some of the explanatory power of the other locational variables.[59] This appears to be the case in the current study, as *Dist_CBD* and *Dist_coast* both loose significance. However, the dummy variable *Cgrove* gains (negative) significance. Given that this variable was positive and significant in the teardown model of Table 2.2, these results imply that teardowns are the major form of redevelopment in Coconut Grove during the sample time period.

Providing support to the notion that demographics may capture idiosyncratic household preferences regarding redevelopment, all neighborhood variables retain their sign and significance, except for *College* and *Black* (although *College%Δ* and *Black%Δ* do remain positive and significant). Of the thirteen neighborhood fixed effects, only two are statistically significant, and these results imply that locations within these two neighborhoods reduce the probability of renovations by approximately 11% to 13%. Additionally, the *Nrenn* and *Ntear* variables remain positively and negatively significant, respectively.

In the teardown model of Table 2.3, the only change in the property variables is that *Age99* looses significance. The variables *ln*(*Lot_sf*), *ln*(*Land_intensity*) and *Lowest_LI* remain strongly significant with the expected signs even in the presence of the neighborhood fixed effects. This provides robust support for the underlying theory regarding urban land values represented by these variables.

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[59] For example, in Weber (2006) most locational variables, which are initially significant, are insignificant when fixed effect variables are added.

As was the case for renovations, the location variables *Dist_CBD* and *Dist_coast* loose significance with the introduction of the neighborhood fixed effects. However, a different finding is that the dummy variable *Cgrove* also becomes insignificant while *Near_golf* becomes positive and significant, which suggests that locations near golf courses may increase the likelihood of teardowns.

The results for the neighborhood variables, where *Population*, *MedFamInc%Δ*, and *College%Δ* are positive and significant, while *Population%Δ* is negative and significant, imply that although most of the prior teardown literature has not utilized demographic variables, the percent changes in measures of population, income, and education may help capture gentrifying areas in ways that the more commonly used variables do not.

Conditional Price Equations

To provide an empirical test of the theorized relationship of the relative implicit market prices of the structural attributes of renovation and teardown properties, the study estimates three separate hedonic models, where each model is conditional on the property's redevelopment status (renovation, teardown, or non-redeveloped) as observed during the two years following the sale of the property. The hedonic models are specified to include all the variables used in the multinomial logit model with fixed effects (i.e.: Table 2.3), except for *ln*(*Land_intensity*), *Lowest_LI*, *Nrenn*, *Ntear*, and *Nrenn*Ntear*.[60] Additionally, quarterly time dummies and a selection bias control (formed from the multinomial logit model with fixed effects) have been added to the hedonic models. Due to space constraints and because the theory being tested

[60] Since most of these variables are significant in the first-stage multinomial logit models, these exclusions ensure that the rank and order conditions necessary for identification of the second-stage hedonic models are satisfied.

concerns only the value of land and the physical attributes, the results for all non-property variables in Table 2.4 have been suppressed.

As reported in the first model of Table 2.4, the property attributes of non-redeveloped properties exhibit the typical values found in most hedonic models of urban housing values. Housing characteristics that add value such as *ln*(*Lot_s*f) and *ln*(*Bldg_sf*) are positive and significant, while those that lower value such as *Age99* reduce value. In fact, all of the structural attributes are statistically significant, and as a result, it is not surprising that the F-test of the null hypothesis that the structural attributes jointly are insignificantly different from zero is strongly rejected.

In the second model in Table 2.4, properties purchased for renovations have been further classified based on intensity of renovation. For major renovations, a dummy variable Ψ_i (which is equal to one if a major renovation and zero otherwise) has been interacted with each of the property's structural attributes. Recall that renovations are classified as major renovations in this study when 45% or more of the structure value has been replaced during the renovation process. Similarly, for non-major renovations, each of the property's structural attributes have been interacted with the term (1- Ψ_i). This specification allows, but does not force, the implicit prices of the structural attributes to vary between major and non-major renovations, which provides a direct test of the theory proposed by Dye & McMillen (2007).

Results from this specification indicate that the interaction terms for the major renovation structural attributes are statistically insignificant, while the interaction terms for non-major renovations remain statistically significant. In addition, an F-test fails to reject the null hypothesis that the structural attributes for major renovations are jointly insignificantly different from zero, although the null is rejected for non-major renovations.[61] These results provide evidence that properties purchased for major renovations are indeed similar to teardown sales, where the property is valued only for the underlying land, while the structural attributes for non-major renovations are similar to non-redeveloped properties, where the structural attributes continue to contribute to the property's value.

Furthermore, results from the model suggest that properties purchased for non-major renovations are in many ways "in-between" non-redeveloped properties and teardowns, where the coefficient for *ln(Lot_sf)* for non-major renovations is much larger than the coefficient for non-redeveloped properties, yet much smaller than the coefficient for teardowns. Similarly, the coefficients on *ln(Bldg_sf)* and *Bedroom* are smaller for non-major renovations than for non-redeveloped properties, yet are greater than the insignificant coefficients for teardowns. These findings are analogous to that of McMillen & O'Sullivan (2012), who find that the value of structural attributes for teardown properties are functions of the estimated probability of redevelopment, where the value of structural attributes decrease as the probability of redevelopment via teardown increases, and vice versa.

In the third model of Table 2.4, the only property attribute of teardowns that is statistically significant is *ln(Lot_sf)*. In addition, the F-test fails to reject the null hypothesis that the structural attributes jointly are insignificantly different from zero. These findings reaffirm the theory that teardowns are valued only for the underlying land. In addition, the selection bias control is significant, but only at the 10% level, which provides some (although weak) evidence that separating renovations from the population of otherwise non-redeveloped housing may help reduce the effects of selection bias in redevelopment studies.

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[61] Although the F-test that the coefficients are jointly equal to zero is significant at the 10% level, in common practice the level of significance is typically set at the 5% level. However, as a robustness check, an F-test is conducted under the null hypothesis that the coefficients are jointly equal to .0001, which fails to be rejected.

Conclusion

When gentrification occurs, low quality housing approaching the end of its economic useful life is redeveloped either in part or in whole into a new or like-new structure, thereby restarting the life cycle of housing once more. If redevelopment in part occurs through renovations, the structure itself remains but the interior and or exterior is substantially remodeled and or expanded. In contrast, if redevelopment in whole occurs through teardowns, the existing structure is completely demolished and a brand new structure is constructed in its place.

Therefore, homeowners that desire to redevelop a specific property face a mutually exclusive decision to either renovate or teardown the existing structure. However, most of the prior gentrification literature has examined renovations and teardowns as separate phenomena, and therefore the relationship between renovations and teardowns has largely been unexplored. Accordingly, this study seeks to link these two literatures within the broader context of gentrification by analyzing how the determinants to renovate differ from teardowns, and by providing an empirical test of the theorized relationship of the relative implicit market value of the structural attributes of both types of redevelopment.

Results from this study indicate that the primary differences in the determinants of renovations and teardowns appear to be variables relating to the size, age, and configuration of the improvements. Structure age increases the likelihood of both renovations and teardowns, but as age increases at an increasing rate the likelihood of renovations decreases while having an insignificant impact on teardowns. Structure size increases the likelihood of renovations while having a statistically insignificant impact on teardowns. The number of bathrooms decreases the probability of renovations but has a statistically insignificant impact on teardowns, suggesting that the addition of bathrooms may be a common motivation for renovations. Overall, these results indicate that, consistent with theory, the existing level of housing services provided by the existing structure is important to renovations, but not to teardowns.

The primary similarities between renovations and teardowns is the importance of location and centrality, where proximity to the CBD and coast are found to increase the likelihood of both renovations and teardowns. Additionally, although renovations and teardowns are found to occur in spatial clusters, as in prior redevelopment studies, this study provides evidence that they occur in separate clusters. In fact, the presence of recent teardowns in a neighborhood lowers the probability of renovations in that neighborhood, and vice versa. This result is plausibly attributed to the homogeneous distribution of housing attributes within, but not among, neighborhoods.

As a new test of the optimal teardown rule proposed by Brueckner (1980) and Wheaton (1982), this study utilizes a proxy variable for this rule. As the ratio of a property's lot value to total value approaches 100%, the structure approaches total economic insignificance, which would (ceteris paribus) make the property an ideal candidate for redevelopment. Results from the study indicate that this proxy variable indeed offers substantial explanatory power for teardowns. In addition, the study extends the theory to renovations, confirms that renovations occur as a means of replacing worn out physical capital. Furthermore, consistent with theory, the highest decile of this proxy variable is negatively correlated with renovations while positively correlated with teardowns.

Furthermore, results from the study indicate that changes in demographic variables (population, income, education, and race) offer more explanatory power than the levels of those variables in both renovation and teardown determinant models. Particularly, the demographic variables offer greater explanatory power in the model of the renovation decision than in the teardown decision, which is consistent with the notion that teardowns are primarily determined by the optimal teardown rule.

In addition to revealing how the determinants of renovation differ from teardowns, the study also tests the theorized relationship of the relative implicit market value of the structural attributes of renovations and teardowns. Results from the conditional price equations provide two important findings in this regard. First, the structural attributes of renovations are found to be less valuable than non-redeveloped properties. This finding supports the theory that to-be-renovated structures are of lower quality (due to some combination of physical depreciation, functional obsolescence, and externalities) on average than structures that are not renovated. Second, properties purchased for major renovations, which are redeveloped to the point that the structure is effectively brand new, are found to be equivalent to teardown sales, where the property is valued only for the underlying land.

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Table 2.1: Variable Definitions, Descriptive Statistics, and Difference in Means Test

This table provides definitions, descriptive statistics, and difference in mean tests for the variables utilized in the econometric models. Each observation in the sample is classified as a renovatio existing structure remains but has been significantly improved), teardown (where the existing structure is demolished in anticipation of redevelopment), or non-redeveloped (where the property renovated or torndown). For the renovation and teardown observations, all property and sale attributes are observed prior to redevelopment. The reported t-values are based on the results of a variance between the groups for each variable (most variances were found to be unequal). The symbols *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.

		(1) Non-Redeveloped		(2) Renovations		(3) Teardowns		(2) - (1) Diff	(3) - (1) Diff
Variables	Variable Definitions	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev	|t-value|	|t-value|
Property									
Sales_price	Sales price of the house	182,053	212,658	205,700	193,200	195,377	172,786	2.57 **	1.22
Lot_sf	Lot size (square feet)	7,080	3,050	8,147	3,919	8,213	4,306	7.72 ***	6.87 ***
Bldg_sf	Interior area (square feet)	1,667	776	1,879	807	1,715	961	6.05 ***	1.16
Bedrooms	Number of bedrooms	2.69	0.84	2.84	0.87	2.64	0.94	3.86 ***	1.17
Bathrooms	Number of bathrooms (half bath = .5)	1.65	0.85	1.82	0.90	1.65	0.96	4.39 ***	0.05
Age99	Sructure age in 1999 (calculation: 1999 - year built)	51.68	15.35	51.68	14.40	55.12	12.96	0.00	4.37 ***
Land_intensity	Assessed land value divided by assessed total value (in the year of sale)	0.47	0.14	0.49	0.14	0.53	0.17	3.20 ***	8.07 ***
Lowest_LI	1 if *land_intensity* is in the lowest 10th percentile, 0 otherwise	0.09	0.28	0.09	0.29	0.25	0.43	0.59	10.58 ***
Location									
Dist_CBD	Miles from the central business district	3.91	1.48	3.77	1.38	3.74	1.33	2.22 **	2.31 **
Dist_coast	Miles from the coastline minus 1 if < 1 mile, 0 otherwise	(0.28)	0.34	(0.40)	0.35	(0.38)	0.34	7.68 ***	5.30 ***
Dist_MIA	Miles from Miami International Airport minus 1 if < 1 mile, 0 otherwise	(0.00)	0.03	(0.01)	0.04	(0.01)	0.05	2.99 ***	2.93 ***
Cgrove	1 if located within Coconut Grove, 0 otherwise. This is a trendy residential & retail area on the southern Miami coast.	0.09	0.28	0.10	0.30	0.18	0.39	0.86	6.52 ***
Near_golf	1 if located within .5 miles of a golf course, 0 otherwise	0.03	0.17	0.07	0.25	0.08	0.27	4.81 ***	5.08 ***
Neighborhood									
Population	Total population in 2000 (census tract)	5,872	1,881	5,579	1,831	5,506	1,819	3.64 ***	3.86 ***
Population%Δ	% change in *Population* from 1990 to 2000	0.02	0.10	0.04	0.14	0.02	0.13	2.93 ***	0.29
MedFamInc	Median family income in 2000 (census tract)	35,780	23,840	41,076	26,143	40,936	27,731	5.02 ***	4.10 ***
MedFamInc%Δ	% change in *MedFamInc* from 1990 to 2000	0.46	0.72	0.74	1.60	0.69	1.29	7.45 ***	5.78 ***
College	% persons 25+ with bachelors degree in 2000 (census tract)	0.22	0.19	0.26	0.20	0.27	0.21	5.16 ***	4.90 ***
College%Δ	% change in *College* from 1990 to 2000	0.31	0.31	0.33	0.26	0.33	0.30	1.54	1.27
Black	% population Black or African American in 2000 (census tract)	0.18	0.29	0.16	0.25	0.19	0.28	1.16	0.97
Black%Δ	% change in *Black* from 1990 to 2000	0.67	1.37	0.83	1.67	0.69	1.49	2.63 ***	0.27
Hispanic	% population Hispanic or Latino in 2000 (census tract)	0.63	0.33	0.58	0.31	0.56	0.32	3.33 ***	4.41 ***
Hispanic%Δ	% change in *Hispanic* from 1990 to 2000	0.10	0.26	0.09	0.19	0.12	0.26	0.67	2.07 **
Nrenn	# of sales that are renovations within .75 miles that occurred during the 3 years prior to the sale of the subject property	29.92	32.12	32.13	31.51	36.51	40.06	1.60	3.86 ***
Ntear	# of sales that are teardowns within .75 miles that occurred during the 3 years prior to the sale of the subject property	4.96	6.59	4.84	6.48	6.45	7.75	0.42	4.29 ***
Observations	Total sample contains 5,496 single family residential transactions	4,501		592		403			

Table 2.2: Multinomial Logit Model of the Redevelopment Decision

This table reports results from the multinomial logit model of the decision to renovate, teardown, or not redevelop (which is the omitted category). The symbols *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.

	Renovate				Teardown			
Variable	Coeff	Marg. Effect	|z-value|		Coeff	Marg. Effect	|z-value|	
Property								
ln(Lot_sf)	0.063	0.001	0.320		0.563	0.036	2.57	**
ln(Bldg_sf)	1.128	0.100	4.620	***	0.261	0.007	0.93	
Bedrooms	0.073	0.007	0.960		-0.087	-0.006	0.94	
Bathrooms	-0.185	-0.017	2.070	**	0.043	0.004	0.40	
Age99	0.026	-4E-04	1.950	*	0.033	0.001	1.77	*
Age99 ^{2}	-3E-04		2.060	**	-2E-04		1.28	
ln(Land_intensity)	1.248	0.104	4.680	***	1.069	0.058	3.40	***
Lowest_LI	-0.309	-0.034	1.670	*	0.656	0.045	3.61	***
Location								
Dist_CBD	-0.107	-0.009	2.410	**	-0.116	-0.006	1.96	*
Dist_coast	-0.928	-0.077	4.230	***	-0.835	-0.046	3.22	***
Dist_MIA	0.650	0.052	0.390		0.771	0.044	0.42	
Cgrove	-0.259	-0.031	0.970		0.822	0.055	3.07	***
Near_golf	0.541	0.036	1.360		1.176	0.071	2.57	**
Neighborhood								
Population	2E-05	0.000	0.420		6E-05	0.000	1.51	
Population%Δ	-3.073	-0.238	3.640	***	-4.760	-0.279	5.04	***
ln(MedFamInc)	2.030	0.178	5.350	***	0.800	0.034	1.95	*
MedFamInc%Δ	0.290	0.023	3.390	***	0.357	0.020	3.88	***
College	-8.271	-0.742	5.140	***	-1.200	-0.005	0.63	
College%Δ	0.950	0.081	4.080	***	0.658	0.034	2.71	***
Black	-2.052	-0.205	1.550		2.132	0.155	1.38	
Black%Δ	0.102	0.009	2.390	**	0.032	0.001	0.57	
Hispanic	-2.767	-0.263	2.350	**	1.274	0.106	0.91	
Hispanic%Δ	0.348	0.028	1.110		0.380	0.021	1.25	
Nrenn	0.013	0.001	2.470	**	-0.010	-0.001	1.54	
Ntear	-0.057	-0.007	2.620	***	0.041	0.004	1.67	*
*Nrenn*Ntear*	-3E-04		1.790	*	2E-04		0.91	
Other								
Constant				Yes				
N				5,496				
Log-Likelihood				-3018.18				

Table 2.3: Multinomial Logit Model of the Redevelopment Decision With Fixed Effects

This table reports results from the multinomial logit model of the decision to renovate, teardown, or not redevelop (which is the omitted category). The neighborhood fixed effects are normalized with respect to a large coastal neighborhood in north Miami. The symbols *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.

	Renovate				Teardown			
Variable	Coeff	Marg. Effect	|z-value|		Coeff	Marg. Effect	|z-value|	
Property								
ln(Lot_sf)	-0.072	-0.011	0.37		0.492	0.032	2.20	**
ln(Bldg_sf)	1.246	0.109	4.98	***	0.349	0.011	1.22	
Bedrooms	0.083	0.008	1.08		-0.073	-0.005	0.77	
Bathrooms	-0.203	-0.018	2.25	**	0.005	0.002	0.05	
Age99	0.017	-0.001	1.29		0.028	4E-04	1.47	
Age99 ^{2}	-2E-04		1.56		-2E-04		1.12	
ln(Land_intensity)	1.488	0.122	5.34	***	1.366	0.074	4.17	***
Lowest_LI	-0.277	-0.030	1.48		0.602	0.041	3.25	***
Location								
Dist_CBD	-0.082	-0.006	0.89		-0.132	-0.008	1.18	
Dist_coast	0.095	0.010	0.29		-0.127	-0.009	0.34	
Dist_MIA	1.058	0.085	0.63		1.171	0.065	0.65	
Cgrove	-1.699	-0.154	3.79	***	0.040	0.018	0.10	
Near_golf	0.181	0.008	0.44		0.920	0.057	1.84	*
Neighborhood								
Population	5E-05	0.000	1.09		1E-04	0.000	2.60	***
Population%Δ	-2.632	-0.198	2.19	**	-4.430	-0.260	3.76	***
ln(MedFamInc)	1.423	0.124	3.45	***	0.458	0.017	1.01	
MedFamInc%Δ	0.387	0.031	3.48	***	0.426	0.024	3.73	***
College	-3.327	-0.308	1.46		0.883	0.086	0.32	
College%Δ	0.742	0.062	2.73	***	0.534	0.028	1.93	*
Black	-1.323	-0.131	0.78		1.376	0.100	0.68	
Black%Δ	0.102	0.009	2.17	**	0.050	0.002	0.84	
Hispanic	-2.035	-0.204	1.15		2.336	0.167	1.10	
Hispanic%Δ	0.252	0.021	0.65		0.153	0.008	0.44	
Nrenn	0.012	0.001	1.98	**	-0.006	0.000	0.88	
Ntear	-0.059	-0.007	2.49	**	0.034	0.003	1.25	
*Nrenn*Ntear*	-3E-04		1.75	*	8E-05		0.40	

Table 2.3: (continued)

Variable	Renovate Coeff	Renovate Marg. Effect	Renovate |z-value|	Teardown Coeff	Teardown Marg. Effect	Teardown |z-value|
Neighborhood Fixed Effects						
NH91 - northern coast	0.254	0.019	0.51	0.466	0.027	0.90
NH92 - west	-0.845	-0.080	1.33	0.473	0.038	0.80
NH93 - west	-0.333	-0.020	0.55	-1.077	-0.066	1.67 *
NH94 - central	0.032	0.004	0.06	-0.105	-0.007	0.19
NH98 - central coast (hotel district)	-1.274	-0.112	1.88 *	-0.293	-0.007	0.46
NH99 - central	-0.626	-0.044	0.74	-1.347	-0.081	1.57
NH100 - west (near airport)	0.390	0.044	0.50	-1.012	-0.068	1.20
NH101 - west (near airport)	-0.840	-0.058	1.09	-2.009	-0.121	2.42 **
NH102 - west (near airport)	-0.878	-0.066	1.29	-1.535	-0.090	2.16 **
NH103 - south central	-0.735	-0.051	1.13	-1.707	-0.102	2.55 **
NH104 - south central	-0.605	-0.042	0.95	-1.371	-0.082	2.11 **
NH105 - south	-1.560	-0.127	3.93 ***	-1.560	-0.086	3.46 ***
Other						
Constant			Yes			
N			5,496			
Log-Likelihood			-2986.69			

Table 2.4: Conditional Price Equations

This table reports results from the price equations, where are conditional on the property's observed redevelopment status during the two years subsequent to the sale transaction. The dependent variable is *ln(Sales_price)*. For the renovation and teardown observations, all property and sale attributes are observed prior to redevelopment. The reported t-values are calculated using heteroskedastic robust standard errors. Ψ is a dummy variable that equals 1 if a major renovation (where renovation costs exceed 43% of the pre-renovated structure value), 0 otherwise. Location, neighborhood, neighborhood fixed effects, and quarterly time dummy variables are included in each of the models but their results have been suppressed. The F-test is a test of the null hypothesis that the coefficients of the structural attributes are jointly equal to zero. The symbols *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.

	Non-Redeveloped			Renovations			Teardowns		
Dependent = *ln(Sales_price)*									
Variable	Coeff	Robust Std Error	|t-value|	Coeff	Robust Std Error	|t-value|	Coeff	Robust Std Error	|t-value|
Property									
ln(Lot_sf)	0.247	0.023	10.68 ***	0.396	0.084	4.71 ***	0.659	0.173	3.80 ***
ln(Bldg_sf)	0.447	0.019	23.56 ***				0.101	0.145	0.70
Bedrooms	-0.020	0.008	2.55 **				-0.018	0.049	0.37
Bathrooms	0.083	0.009	8.84 ***				0.085	0.056	1.50
Age99	-0.007	0.001	4.86 ***				0.014	0.013	1.11
Age99^2	5E-05	1E-05	3.64 ***				-1E-04	1E-04	0.93
*ln(Bldg_sf)*Ψ*				0.051	0.276	0.18			
ln(Bldg_sf)(1-Ψ)*				0.331	0.126	2.62 ***			
*Bedroom*Ψ*				-0.062	0.175	0.36			
Bedroom(1-Ψ)*				-0.042	0.035	1.20			
*Bath*Ψ*				0.108	0.177	0.61			
Bath(1-Ψ)*				0.099	0.049	2.02 **			
*Age99*Ψ*				0.042	0.064	0.66			
Age99(1-Ψ)*				-0.012	0.006	1.89 *			
Age99^2 **Ψ*				-2E-04	0.001	0.43			
Age99^2 **(1-Ψ)*				9E-05	7E-05	1.30			
Location		Yes			Yes			Yes	
Neighborhood		Yes			Yes			Yes	
Neighborhood Fixed Effects		Yes			Yes			Yes	
Other									
Quarterly time dummies		Yes			Yes			Yes	
Constant		Yes			Yes			Yes	
Selection bias correction	0.102	0.085	1.21	-0.035	0.195	0.18	0.459	0.257	1.79 *
N		4,501			210			136	
Adj R^2		0.824			0.820			0.841	
F-test (structural attributes = 0)		272.57***						1.44	
Major Renovations: F-test					2.18*				
Renovations: F-test					9.34***				

APPENDIX A

IDENTIFICATION OF TEARDOWNS

This appendix details the teardown identification process used in this paper. Although most redevelopment studies use demolition permits to identify teardowns, the demolition permit data obtained from the City of Miami Building Department was deemed to be incomplete. Therefore, a panel data set is constructed from the real property tax roll files for Miami-Dade County obtained from the Florida Department of Revenue in order to identify teardowns.

The file contains a variety of property-level measures such as year built, effective year built, interior area, lot size, land use, and the value of any improvements constructed or demolished during the year (which is based on building permit data obtained by the tax assessor's office), as well as sales transactions and assessed values. Because the same characteristics are reported for each property each year, a panel data set can be constructed which allows for teardowns to be identified.

A property is identified as a teardown in this study if one of the four following conditions is satisfied:

> Condition 1: If 50% or more of the previous year's structure value is demolished. In the example provided in Table A.1, 100% of structure value has been demolished, so this meets this algorithm's requirement and the property is identified as a teardown.
>
> Condition 2: If the state land use code changes from improved residential or improved commercial to vacant residential. In the example, the land use code changes from improved single family residential to vacant residential. (Subsequently, the land use

codes changes back from vacant to single family residential). Therefore, this meets this algorithm's requirement and the property is identified as a teardown.

Condition 3: If year built increases and interior area is not equal to the previous year's interior area and some structure value has been removed (all of which must occur in the same year). In the example, the year built changed from 1960 to 0, interior area changed from 3,002 sf to 0, there was some (in this case all) of the structure value removed, and all of these events occurred in the same year. (Subsequently, the interior area changes from 0 to 5,974 and $907,626 in building value was constructed). Therefore, this meets this algorithm's requirement and the property is identified as a teardown.

Condition 4: If the property is on the demolition permit file obtained from the City of Miami Building Department. In the below example, this property was not contained in the demolition permit file. However, clearly the data reveal that this property was redeveloped.

It should be noted that although three of the above conditions identified the property in the below example as a teardown, this was not always the case. Most of the teardowns in our sample where identified as such by two conditions, while a minority of teardowns were identified by only one condition. When our panel teardown list (which resulted in 403 teardowns, 7% of the final sample) is compared against the demolition permit file obtained from the City of Miami Building Department (which contained 92 residential demolition permits), our teardown list successfully captured 93% of the demolition permits for properties common to both the permit list and the Department of Revenue files during the sample time frame. Therefore, this appears to be a novel, yet valid, approach to identifying teardowns.

APPENDIX B

IDENTIFICATION OF RENOVATIONS

This appendix details the process used to identify renovations in this paper, which is very similar to the method used to identify teardowns. A property is identified as a renovation in the sample according to the below algorithm. (An illustration of the identification process detailed in this appendix is given in Table B.1).

The total amount of structure value added for each property (as identified by the Miami-Dade County Tax Assessor) is summed up from the first year of renovation activity until 2004. If this sum is greater than $2,000, the sum is then divided by the building assessed value in the year prior to the first year of renovation activity to calculate the "renovation ratio". If the renovation ratio is greater than 2% and the following filters are met (state land use code must indicate improved single family, last sales price > $50,000, building assessed value > $25,000, interior area > 300 sf, lot size > 1,500 sf), then the observation is classified as a renovation. Furthermore, a property is identified as a major renovation if the renovation ratio exceeds 45%.

Table A.1: Teardown Identification

The below is a sub-sample of data fields contained in the original data files (some variable names were changed for tractability). A brief explanation of some of the variables follows. *State land use code*: "01" indicates improved single family residential and "00" indicates vacant residential. *Structure Value Added or Removed*: a positive number indicates the value of new improvements added to the property, while a negative number indicates the value of improvements that were demolished.

Property Identification Number	Tax Roll Year	State Land Use Code	Total Assessed Value	Land Assessed Value	Building Assessed Value	Structure Value Added or (Removed)	Effective Year Built	Actual Year Built	Interior Area (sf)	Lot Size (sf)
0132190081050	1999	01	$ 255,296	$ 138,188	$ 117,108	$ -	1960	1960	3,002	19,960
0132190081050	2000	01	$ 306,636	$ 169,595	$ 137,041	$ -	1960	1960	3,002	19,960
0132190081050	2001	01	$ 341,037	$ 186,554	$ 154,483	$ -	1960	1960	3,002	19,960
0132190081050	2002	01	$ 361,611	$ 239,520	$ 122,091	$ -	1960	1960	3,002	19,960
0132190081050	2003	00	$ 359,280	$ 359,280	$ -	$ (122,091)	.	.	.	19,960
0132190081050	2004	00	$ 395,208	$ 395,208	$ -	$ -	.	.	.	19,960
0132190081050	2005	01	$ 1,480,478	$ 572,852	$ 907,626	$ 907,626	2004	2004	5,974	19,960

Table B.1: Renovation Identification

The below is a sub-sample of data fields contained in the original data files (some variable names were changed for tractability). A brief explanation of some of the variables follows. *Renovation Ratio* is the sum of *Structure Value Added or Removed* from the first year of renovation activity to 2004, divided by the structure value in the year prior to the first year of renovation activity. *State land use code*: "01" indicates improved single family residential. *Structure Value Added or Removed*: a positive number indicates the value of new improvements added to the property, while a negative number indicates the value of improvements that were demolished.

Property Identification Number	Tax Roll Year	State Land Use Code	Total Assessed Value	Land Assessed Value	Building Assessed Value	Structure Value Added or (Removed)	Renovation Ratio	Effective Year Built	Actual Year Built	Interior Area (sf)	Lot Size (sf)
0131330040030	1999	01	$ 90,656	$ 47,250	$ 43,406	$ -	.	1954	1947	1,401	6,300
0131330040030	2000	01	$ 97,164	$ 51,975	$ 45,189	$ 240	.	1954	1947	1,401	6,300
0131330040030	2001	01	$ 124,455	$ 51,975	$ 72,480	$ 9,975	0.24	1997	1947	1,732	6,300
0131330040030	2002	01	$ 144,952	$ 51,975	$ 92,977	$ -	.	1997	1947	1,732	6,300
0131330040030	2003	01	$ 159,367	$ 54,495	$ 104,872	$ -	.	1997	1947	1,732	6,300
0131330040030	2004	01	$ 180,641	$ 70,875	$ 109,766	$ -	.	1997	1947	1,732	6,300
0131330040030	2005	01	$ 221,377	$ 102,690	$ 118,687	$ -	.	1997	1947	1,732	6,300