On the value of market signals: Evidence from commercial real estate redevelopment ⋆,⋆⋆

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Abstract

We investigate how institutional commercial real estate investors adapt their investment decisions according to tangible localized market signals. We find that investors are more likely to implement buy-to-redevelop strategies in a given area when recent investments signal the existence of a capital intensity gap and economic activity mismatch between older buildings and newly built ones. Our analysis shows that investors deem these information externalities valuable. Ceteris paribus, when real estate investments signal obsolescence of the existing stock, investors are willing to pay up to 30% more to acquire a property for redevelopment. Our findings contribute to the literature on pricing market signals and provide insights for policymakers to stimulate commercial real estate investments and urban renewal.

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1. Introduction

A common decision real estate investors have to make is whether to purchase a property and keep it 'as is', or modify its characteristics. The value of the possibility to reconfigure a real asset – the so-called real option value – is determined by its ability to generate more revenue in the new configuration (intrinsic value) and by the flexibility for the investors to choose when to exercise the option (time value). Despite the pervasiveness of real options in many fields of finance, empirical studies investigating real options remain scarce, and primarily focus on the timing of exercise decisions by asset owners.[1] Virtually nothing is known about how the intrinsic value of real options might affect initial investment decisions. More precisely, which market signals might lead investors to purchase an asset to reconfigure its characteristics immediately? How do these market signals affect the investors' willingness to pay via the real option value attached to the asset? To address these questions, we empirically investigate how institutional investors adapt their buy-to-redevelop strategies according to tangible localized market signals.

Characterizing and pricing market signals that influence investment decisions via real options is challenging for several reasons. First, data on the investment purpose is usually unavailable. Second, as pointed out in the literature (Garmaise and Moskowitz (2004), Kurlat and Stroebel (2015), Agarwal et al. (2018), and Francke and Van de Minne (2021)), real estate markets have heterogeneous assets, infrequent sales, and potentially differentially informed agents. This makes it hard to discern market trends only via price signals. Moreover, market trends in commercial real estate encompass the subtle shifts and hidden dynamics that are often unobserved. These trends can significantly impact the commercial real estate market. Identifying unobserved market trends in commercial real estate involves examining factors beyond traditional market indicators. In such a context, relevant market signals might go unnoticed by less experienced investors or be pertinent only for specific sub-asset classes. Third, because redevelopment entails larger risks than keeping the real asset unchanged, there is a potential reverse causality between the likelihood of purchasing

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[1] See, for example, Quigg (1993), Moel and Tufano (2002), Kellogg (2014), and Décaire et al. (2020).

an asset to immediately exercise the real option and the investor's willingness to pay. Finally, to isolate the impact of the investors' intent to redevelop on their willingness to pay, we need to account for the micro determinants of the asset's ability to generate revenue in its current configuration.

To meet the above challenges, we structure our analysis as follows. First, we use a rich database of commercial real estate transactions in the US from 2001 to 2018. A distinctive feature of the data is that it contains information on whether investors purchase a commercial property for immediate redevelopment, i.e., demolishing the existing structure to construct a new building.[2] Second, the data set focuses on transactions between large institutional investors, which are arguably less prone to be differentially informed. In addition, we focus on *tangible*, i.e., easily observable signals that serve as indicators for unobservable market trends. These signals include the intensity of capital invested per unit of land and the type of economic activity chosen by real estate investors recently investing in a local area. Third, by developing a simple theoretical framework, we show how to exploit these market signals to devise a novel identification strategy addressing reverse causality issues when pricing the investors' intent to redevelop. Finally, the data allows us to control for the assets' ability to generate revenue, and buyers' and sellers' characteristics.

We find that the larger the capital intensity gap between a given commercial property and nearby recently built ones – a situation that typically occurs when taller buildings are built in the proximity of the considered property – the higher the likelihood that investors purchase the property for immediate redevelopment. This implicitly assumes that developers always build to the highest and best use (HBU), given existing local market conditions and land-use regulations. As pointed out by Leather (2022), when an area experiences rezoning, neighbors that did not experience the rezoning reevaluate their expectations about their future zoning designation. Interestingly, the effect of the capital intensity gap is larger in magnitude than the one of capital depreciation, a main determinant of real option exercise advocated in the literature (see Clapp and Salavei (2010)). A one standard deviation increase in the capital

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[2] In the US, investors must disclose to financial institutions providing a mortgage loan their intent to purchase a property for redevelopment. Note that we refrain from analyzing renovations since renovations can be anything from a new lobby area to an entirely new interior for a property.

intensity gap (capital depreciation) increases the 'buy-to-redevelop' likelihood, on average, by 29% (11%) in relative terms. A mismatch between the current type of economic activity – residential, retail, industrial, or offices – of a given commercial property and the one of nearby recently built properties also increases the propensity to purchase the property for immediate redevelopment, although to a lower extent. Geographically close investments signaling a capital intensity gap and an economic activity mismatch spur the immediate exercises of redevelopment options. In contrast, more distant signals act as a deterrent. Finally, our most conservative estimates show that the capital intensity gap and economic activity mismatch capitalize, ceteris paribus, up to 30% higher transaction prices via the asset's intrinsic real option value. This highlights the importance of market signals.

The following steps compose our empirical analysis. First, we operationalize the two types of tangible market signals. We define the capital intensity gap of a given property as the ratio between its Floor to Area Ratio (FAR) and the average FAR of recently built nearby buildings.[3] Similarly, we define an index of economic activity mismatch as the ratio of recently built nearby properties with a type of economic activity that differs from the one of a given building. Next, we investigate how these tangible signals affect the likelihood that institutional investors purchase a real estate asset for redevelopment using a standard probit model. Finally, following Wooldridge (2010), we use a three-stage least square procedure (3SLS) to estimate investors' willingness to pay for a commercial property for redevelopment. More in detail, we use the predicted probabilities from the probit model to instrument the investors' intent to redevelop in a hedonic pricing equation.

The first identification assumption of our empirical approach is that investors consider market signals valuable only via the real option attached to the asset. This assumption is violated if recent nearby development exerts positive externalities on the building's value. To ensure that this does not bias our results, we control for buildings' ability to generate revenue. This internalizes any positive externality, particularly since we focus on tangible and easily observable market signals. Moreover, we run several robustness checks. First, we

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[3] The building's FAR is the sum of the area of each floor, divided by the building plot's land area. Because the amount of capital invested in a building increases with the total building surface, the FAR is a good proxy for the capital invested per unit of land.

partial out county fixed effects interacted with year fixed effects. These interaction terms address omitted variable concerns regarding the investors' expectations and risk perceptions of local real estate markets. Second, we control for the net operating income (NOI) per square meter generated by recently built nearby properties, which serves as a proxy for the value of positive externalities. Third, we drop the recent developments within 1000 meters of a redevelopment to eliminate the possible positive externalities on the building's value. Fourth, we lag our market signals. This ensures that recently nearby built properties do not exert positive externalities on the future revenue-generating ability of existing properties. Our results are left unchanged.

The second identification assumption is that the considered market signals are unrelated to price unobservables conditional on our set of controls. Because we condition on the building's ability to generate revenue, such a correlation must stem from a relationship between price-relevant investors' characteristics and market signals. This violation of the instruments' exogeneity seems unlikely. In our preferred specifications, we control for several buyers' characteristics, such as capitalization type, investors' geographic scope, and whether investors are foreign.[4] Additionally, our empirical analysis provides several results indirectly supporting the instruments' exogeneity. When using both market signals – capital intensity gap and economic activity mismatch – separately in the 3SLS estimations, estimates of the willingness to pay for redevelopment converge toward similar estimates that are not statistically different from each other. Put differently, if one or both instruments were endogenous, the results would not converge in probability towards the true population parameter. Finally, when we jointly use both instruments, the overidentification test does not indicate endogeneity issues.

Our paper contributes to the existing literature in several ways. First, by estimating how tangible market signals affect the investors' willingness to pay for real asset redevelopment,

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[4] Controlling for the foreign status of an investor seems important in light of the recent literature. As pointed out by Chinco and Mayer (2015) and Agarwal et al. (2018), investors unfamiliar with a local real estate market tend to misprice real estate assets due to information asymmetries. Additionally, Badarinza and Ramadorai (2018) show the importance of a safe-haven effect leading foreign investors a bid higher prices to invest their capital in politically safer countries.

we provide novel empirical evidence on the mechanisms hypothesized in the real options literature. Specifically, we find that tangible market signals represent a valuable information externality for other investors, as theorized by Grenadier (1996), Grenadier (1999), Grenadier (2002), and Grenadier and Malenko (2011). In doing so, our study establishes a new link between market signals and the real options framework by Capozza and Li (1994) and Capozza and Li (2002). In particular, we show that investors use market signals to assess a property's highest and best use in terms of capital intensity and type of economic activity and that this has substantial repercussions on their willingness to pay.

Second, we expand the current literature investigating real options empirically. Existing empirical studies – such as Décaire et al. (2020), Kellogg (2014), Moel and Tufano (2002) in the case of gas, oil, and mining activities, respectively – primarily focus on the *timing* of exercising real options, and on the time value of real options (Quigg (1993)). A few studies investigate the link between the redevelopment of residential properties and land values (Munneke (1996) Dye and McMillen (2007)) and how the option to redevelop a residential property might affect the valuation of its hedonic characteristics (Clapp and Salavei (2010), Clapp et al. (2012), and Munneke and Womack (2018)). We contribute to this literature by i) investigating how real options might affect *initial* investment decisions by commercial real estate investors[5], ii) quantifying the importance of tangible market signals, and iii) implementing a novel empirical identification strategy allowing to assess how much investors value the possibility of redeveloping the real estate asset.

Empirically pricing how much investors value real options seems particularly important given two main limitations of existing pricing models. Standard stochastic real option valuation models rely on strong assumptions when calibrating the structural parameters characterizing the behavior of the underlying asset. Compared to financial assets, durable assets – such as real estate assets – are traded with low frequency. Therefore, parameters describing

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[5] The lack of research on real options in commercial real estate may strike as surprising given the sheer size of the commercial real estate market and its importance for the economy. According to CoStar All Properties Database 2018 and Costar's Real Estate Market Size Estimates 2018, the commercial real estate market was worth about 17 trillion USD, making it one of the most important asset classes for investors. For comparison, the total market capitalization of the US stock market was 32 trillion USD in 2018, and the bond market was valued at 29 trillion in 2018, according to SIFMA.

the mean and dispersion of the underlying asset dynamics are usually assumed to be the same for large geographic areas, typically at the MSA or national level in the case of the US market. This assumption potentially neglects significant spatial heterogeneity in the local market fundamentals that will likely affect the timing and value of real options. Given the granularity of our data, we can tease out such local determinants without imposing strong assumptions. A second limitation of existing pricing models comes from the assumption that there is only one underlying asset. In the case of real options, this should not be the case. To the extent that investors can choose among different economic activities – each characterized by different underlying rent dynamics – when reconfiguring the tangible asset, multiple interdependent stochastic processes are relevant to compute the real option value. As pointed out by Lambrecht (2017), real option valuation becomes theoretically intractable when several state variables are considered. Our empirical approach overcomes this issue.

The remainder of the paper is structured as follows. Section 2 introduces the theoretical framework. Section 3 presents the empirical methodology and discuses the identifying assumptions. Section 4 describes the data and the construction of several measures. Section 5 shows the results and robustness checks. Section 6 concludes.

2. Theoretical framework

To lay out the fundamental mechanisms behind the exercise and valuation of redevelopment options, we build on the work of Capozza and Li (1994) and Clapp and Salavei (2010). We develop a simple theoretical framework allowing us to i) rationalize the empirical specifications illustrated in Section 3 and ii) formalize an approach to handle the endogeneity issues related to estimating the redevelopment option value.[6] Importantly, to be consistent with the empirical analysis, our focus is on the option's *intrinsic* value to redevelop and not on its time value.[7] We provide details on the mathematical derivations in Appendix A.

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[6] Our aim is not to carry out market simulations with calibrated parameters. Instead, we remain in a partial equilibrium setting and focus on the channels we can investigate empirically. The main advantage of this approach is that we do not need to solve the model's equilibrium, which might not be feasible if several underlying assets – in our case, the value of buildings carrying out different types of economic activity – affect the option value to reconfigure the real asset.

[7] For this reason, we choose a certainty framework and refrain from modeling stochastic time dynamics.

Let P_{it} denote the value of commercial property i at time t. The property generates a periodic NOI $y_{is}c_{is}$ in $s \geq t$, where y_{is} and c_{is} denote the NOI per unit of building capacity and the total building capacity, respectively.[8] Building capacity is the output of a Cobb-Douglas production function displaying constant returns to scale. The production factors are land L_i and capital C_{is}, i.e., $c_{is} = AL_i^{\alpha}C_{is}^{1-\alpha}$, where $0 < \alpha < 1$ denotes the land output elasticity, and A the total factor productivity.[9] The land component of the building capacity is time-invariant, whereas the capital-investment component depreciates at a constant rate ρ. Thus, the total building capacity decreases over time.[10] Finally, we assume a constant discount rate r and that investors expect the net revenue y_{is} to grow continuously at a constant rate g.[11]

Let P_{it}^{N} and P_{it}^{R} denote the price of a given real estate property that is *never* redeveloped and that is redeveloped once, respectively. Because investors will choose the alternative that maximizes the building value, it follows that $P_{it} = \max(P_{it}^{N}, P_{it}^{R})$. It can be shown that $P_{it}^{R} = P_{it}^{N} + V_{it}^{R}$, where V_{it}^{R} is the additional value created by redeveloping the building (which can be negative). This leads to $P_{it} = P_{it}^{N} + \max(0, V_{it}^{R})$, where $\max(0, V_{it}^{R})$ is the redevelopment option value. Using a standard present value approach, the value of a property built at time $t_0 < t$ that is never redeveloped is given by

$$P_{it}^{N} = \frac{y_{it}AL_iS_{it_0}^{1-\alpha}}{r + (1-\alpha)\rho - g}e^{-(1-\alpha)\rho(t-t_0)}, \tag{1}$$

where $S_{it_0} = C_{it_0}/L_i$ is the capital to land ratio – which represents a measure of the intensity of capital investment at the time the building was built. As expected, the value of a building that is never redeveloped unequivocally decreases with building age $t - t_0$ due to physical depreciation.

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[8] We interpret capacity as the floor area of the real estate asset. We abstract from quality considerations, which we assume are captured in the term y_{is}. However, in our empirical specifications, we do control for terms proxying the hedonic quality of the real estate asset.

[9] This formulation is common in the urban literature. See, for example, Brueckner (1987).

[10] In Section 5.5, we check the validity of our results when considering alternative non-linear depreciation rates.

[11] In our empirical analysis, we relax these assumptions by including time and county-level fixed effects. This allows for potential time and space heterogeneity in the investors' expectations.

Investors optimize the additional redevelopment value V_{it}^{R} along two main dimensions, namely the optimal time of redevelopment T and the intensity of capital investment S_{it}^{*R}.[12] Because we conceptually allow investors to change the 'best use' of the property when redeveloping – for example switching from renting offices to renting residential housing units – we denote by y_{it}^{*R} the after-redevelopment unitary NOI. This income is not necessarily generated by the same market segment as before exercising the real option. Given our empirical focus on the intrinsic value of redevelopment, let us set $T = t$. This implies that the current period is deemed optimal by investors to redevelop, i.e., its intrinsic value determines the option value. It follows that

$$V_{it}^{R} = \frac{L_i}{r + \rho(1-\alpha) - g}\left(y_{it}^{*R} A S_{it}^{*R,1-\alpha} - y_{is} A S_{it_0}^{1-\alpha} e^{-(1-\alpha)\rho(t-t_0)}\right) - L_i K(S_{it_0}, S_{it}^{*R}), \qquad (2)$$

where $K(S_{it_0}, S_{it}^{R}) = k_0 S_{it_0} + k_1 S_{it}^{*R}$ is the cost of redevelopment. We assume this cost is proportional to the initial capital intensity (due to demolition costs) and the intensity of newly invested capital (due to construction costs). Equation (2) implies that the option value of the redevelopment $\max(0, V_{it}^{R})$ unequivocally increases with building age $t - t_0$. This is because the forgone revenue generated by the never-to-be-redeveloped building decreases over time due to depreciation. Additionally, a higher redevelopment option value is reached, ceteris paribus, for higher post-redevelopment NOI and/or higher capital intensity.

Combining (1) and (2) yields

$$\begin{aligned} P_{it} &= P_{it}^{N} \max\left(\frac{y_{it}^{*R} S_{it}^{*R,1-\alpha} e^{(1-\alpha)\rho(t-t_0)}}{y_{is} S_{it_0}^{1-\alpha}} - \frac{K e^{(1-\alpha)\rho(t-t_0)}}{y_{is} A S_{it_0}^{1-\alpha}}, 1\right) = \\ &= P_{it}^{N} r^{Pot}\left(\frac{y_{it}^{*R}}{y_{is}}, \frac{S_{it}^{*R}}{S_{it_0}}, t - t_0\right), \end{aligned} \qquad (3)$$

where the function r^{Pot} denotes the *redevelopment potential value* associated with the property when the new configuration corresponds to the HBU.[13] In the case of no redevelopment

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[12] In Appendix A, we derive expressions for the optimal stopping time T and level of capital intensity S_{it}^{*R}.

[13] To simplify the notation, we do not show level variables among the function's arguments r^{Pot}. However, in our empirical analysis, we consider level variables when estimating the redevelopment potential.

potential, $P_{it} = P^N_{it}$. The redevelopment potential r^{Pot} is an increasing function of $\frac{y^{*R}_{it}}{y_{is}}$, $\frac{S^{*R}_{it}}{S_{it_0}}$ conditional on y_{is} and S_{it_0}, provided the construction cost parameter k_1 is not too large. This implies that, ceteris paribus, redevelopment might be advantageous for investors under two circumstances besides high capital depreciation levels. The first case is when the post-redevelopment HBU NOI largely outweighs the pre-redevelopment one. The second case is when the property can be reconfigured to a higher capital intensity at a reasonable cost.

3. Empirical analysis

3.1. From model to empirics

Using (1) and (3), we obtain a log-log hedonic specification for the value property i at time t, which includes a term for the property's redevelopment potential value

$$\begin{aligned}\ln P_{it} = {} & c + \ln(y_{is}) + (1-\alpha)\ln(S_{it_0}) - (1-\alpha)\rho(t-t_0) + \ln L_i \\ & + \ln r^{Pot}\left(\frac{y^{*R}_{it}}{y_{is}}, \frac{S^{*R}_{it}}{S_{it_0}}, t-t_0\right) + \epsilon_{it},\end{aligned} \tag{4}$$

where the constant $c = -\ln(r+(1-\alpha)\rho) - g$ gathers constant parameters across properties.[14] The term ϵ_{it} is a stochastic error term.

Estimating (4) is challenging because r^{Pot} depends on several unobservables in a nonlinear way. In our case, however, we observe a dummy variable D^{Red}_i that describes an investor's stated intention to purchase a commercial property to redevelop immediately. We can thus proxy the redevelopment potential value term $\ln r^{Pot}_{it}$ in (4) as

$$\ln r^{Pot}_{it} = \gamma + \beta D^{Red}_{it} + \eta_{it}, \tag{5}$$

where D^{Red}_{it} is an *observed* dummy variable that equals 1 if an investor decides to buy property i for redevelopment purposes at time t, and 0 otherwise. The term η_{it} is a stochastic error term capturing the investors' idiosyncratic preferences for redeveloping a property. Equation

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[14] Note that the lower bound of the function r^{Pot} is 1, such that the term $\ln r^{Pot} \geq 0$. This non-negativity comes from the right, but not the obligation, for an investor to exercise a real option.

(4) tells us that D_{it}^{Red} is an indicator function $D_{it}^{Red}(\frac{y_{it}^{*R}}{y_{is}}, \frac{S_{it}^{*R}}{S_{it_0}}, t-t_0)$ that takes a value equal to 1 if the value of at least one of its arguments is high enough.

We thus obtain the following hedonic pricing equation

$$\ln P_{it} = c' + \ln(y_{is}) + (1-\alpha)\ln(S_{it_0}) - (1-\alpha)\rho(t-t_0) + \ln L_i + \beta D_{it}^{Red} + \epsilon'_{it}, \tag{6}$$

where the coefficient β is the parameter of interest and the new terms c' and ϵ'_{it} include γ and η_{it}, respectively.

According to (5), the parameter β estimated in the hedonic equation (6) can be interpreted as follows. Assuming that, on average, investors are rational and purchase commercial properties for redevelopment only when these latter have reached their optimal exercise time, we have

$$\beta = E\left(\ln r_{it}^{Pot} | D_{it}^{Red} = 1\right) - E\left(\ln r_{it}^{Pot} | D_{it}^{Red} = 0\right) = E\left(\ln\left(\frac{r_{it}^{Pot}}{r_{it^*}^{Pot}}\right)\right), \tag{7}$$

where E is the expectation operator, and $r_{it^*}^{Pot}$ denotes, in a slight abuse of notation, the redevelopment potential of properties that is not currently optimal to redevelop. The coefficient β thus corresponds to the average (log of the) ratio of the current optimal redevelopment potential relative to the redevelopment potential of the buildings that are *not* purchased for redevelopment. Put differently, the investor's willingness to pay to acquire a property for immediate redevelopment depends not only on the property's redevelopment potential but also on the redevelopment potential of the other properties that might be optimal to redevelop in the future. The higher the redevelopment potential at a later date, the lower the investor's willingness to pay to acquire a property for immediate redevelopment.

3.2. Potential endogeneity issues and identification strategy

To consistently estimate the parameter β in (6) by OLS, the exogeneity assumption of the intention to redevelop dummy $E[D_{it}^{Red}\epsilon_{it}|X_{it}] = 0$ must hold, where the vector X_{it} denotes the set of model-based controls. This hypothesis is likely violated in two main cases.

The first case is given by the bias arising from omitted variables. Equation (6) shows that not controlling for the property NOI (y_{it}), capital intensity (S_{it_0}), or age ($t - t_0$) leads to biased estimates of β, as these variables likely correlate with the intention to redevelop D^{Red}. This type of bias is a serious limitation in empirical studies that estimate hedonic equation (6) by OLS without controlling for these model-based variables due to data limitations. Omitted variable bias might also arise due to unobservables contained in the error term ϵ_{it} that are not modeled in standard pricing models. As pointed out by Clapp and Salavei (2010), unobservables contained in the error term ϵ_{it} of the hedonic pricing equation might capture buyers and sellers idiosyncratic characteristics. To the extent that these characteristics correlate with the real estate investor's intrinsic willingness to acquire a property for redevelopment, the coefficient β will be biased when estimated by OLS. Our empirical analysis partially addresses the omitted variable bias by including all the controls suggested by our theoretical framework, additional hedonic characteristics, and several buyers and sellers characteristics.

In the second case, the coefficient β is biased due to reverse causality, which occurs when the price P_{it} affects the investor's intention D_{it}^{Red} to acquire a real estate asset for redevelopment purposes. Reverse causality bias might arise because observed buy-to-redevelop strategies are decision outcome that depends on the capacity and willingness of investors to implement such strategies. Put differently, D_{it}^{Red} is not necessarily simply a variable that proxies the accounting relationship in (4). Rather, it results from the optimization of investment decisions by investors. As illustrated in Section 5.2, this is likely to happen due to the larger financial risk associated with redevelopment projects. We argue that the direction of reverse causality bias is negative, as higher prices decrease the probability of acquisition for redevelopment, implying that not taking this mechanism into account might lead to estimates of β that are too low.

To address the above endogeneity issues, we use the following three-step instrumental variable approach (3SLS) outlined in Wooldridge (2010). As pointed out by Wooldridge (2010), this procedure has the main advantage of producing more efficient causal estimates of β compared to a standard 2SLS procedure in which we instrument D_{it}^{Red}.[15] We proceed as

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[15] In the robustness Section 5.5, we verify this claim, thereby justifying the choice of the approach.

follows. Let us assume that we have a set of instruments Z_{it} for the intention to redevelop $\hat{D}_{it}^{Red}$ in the hedonic equation (6). The selection of potential candidates is discussed in the next paragraph. First, we predict the probability $\hat{D}_{it}^{Red}$ of purchasing a real estate asset for redevelopment using the following probit model for the determinants of redevelopment

$$\text{1st stage} \qquad Pr(D_{it}^{Red} = 1 | X_{it}, Z_{it}) = \Phi(\theta_0 + \theta_1 X_{it} + \theta_2 Z_{it}), \tag{8}$$

where Φ is the cumulative standard normal distribution function, and the vector Z_{it} contains the instrumental variables. Next, we estimate (6) by instrumenting D_{it}^{Red} with the predicted probabilities $\hat{D}_{it}^{Red}$. Specifically, the second stage of the 3SLS procedure is given by

$$\text{2nd stage} \qquad D_{it}^{Red} = \gamma_0 + \gamma_1 \hat{D}_{it}^{Red} + \gamma_2 X_{it} + \epsilon_{it}^{*}. \tag{9}$$

The variable ϵ_{it}^{*} is the stochastic error term. The third step of the procedure is given by the equation

$$\text{3d stage} \qquad \ln P_{it} = c' + \beta \hat{\hat{D}}_{it}^{Red} + \gamma' X_{it} + \epsilon_{it}', \tag{10}$$

where $\hat{\hat{D}}_{it}^{Red}$ are the predicted values from (9). For this procedure to provide unbiased estimates of β, the set of instruments contained in Z_{it} must be relevant to predict D_{it}^{Red}, exogenous to unobserved dynamics ϵ_{it}', and satisfy the exclusion restriction.

Our theoretical framework suggests two potential instruments that are relevant and satisfy the exclusion restriction *conditional on the set of controls*: The (the log of) NOI and capital intensity gaps $\frac{y_{it}^{*R}}{y_{is}}$ and $\frac{S_{it}^{*R}}{S_{it'}}$, respectively. These two variables enter the hedonic pricing equation (4) exclusively via the redevelopment potential r^{Pot} function. To the extent that they correlate with the observed intention to redevelop D_{it}^{Red}, these variables are good candidates for being relevant instruments satisfying the exclusion restriction. The question then arises of how to measure the highest and best use (HBU) quantities y_{it}^{*R} and S_{it}^{*R}. We argue that, under the assumption that developers always build to the HBU given existing local market conditions and constraints to development, these variables are given by the observed income and capital intensity of recently built nearby properties.[16]

Given the characterization of HBU variables, we claim that $\frac{y_{it}^{*R}}{y_{is}}$ might not fulfil the exclusion restriction. This is because demand shocks to the market segment of newly built nearby properties – which affect the NOI y_{it}^{*R} – ripple via equilibrium adjustments to the market of existing properties, thereby affecting y_{it}. In other words, the level of y_{it}^{*R} might affect the transaction price P_{it} via adjustments of y_{it}, thereby violating the exclusion restriction.[17] In our empirical analysis, we thus refrain from using $\frac{y_{it}^{*R}}{y_{is}}$ as an instrument.

This violation of the exclusion restriction does not arise in the case of variables S_{it}^{*R} and S_{it}. The original capital investment at time t_0, which does not adjust to new market shocks without redevelopment, drives the cross-sectional variation in the capital intensity level S_{it}. Following this argument, we derive an alternative instrument that aims to capture the time-invariant component of $\frac{y_{it}^{*R}}{y_{is}}$. More precisely, we define this alternative instrument as the mismatch between the existing building usage – which we assume static if no redevelopment occurs – and the building usage of newly built nearby commercial properties.

The exogeneity of the two instruments hinges on the assumption that conditional on all the controls, 'historic' outcomes levels – such as capital intensity and building usage – are uncorrelated with unobserved contemporaneous dynamics contained in ϵ_{it}.[18] This seems reasonable, as the average age of properties purchased with the intention to redevelop is about half a century. Thus a correlation between the instrumental variables and ϵ_{it} is unlikely. This seems especially true given the extensive set of controls we use. We further support this claim in several ways. In Section 5, we perform an overidentification test by regressing the two instrumental variables directly on D_{it}^{Red} and do not find evidence of endogeneity issues. Additionally, in Section 5, we verify that our results remain stable when excluding 'younger' properties from those purchased for redevelopment, likely reinforcing our exogeneity claims.

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[16] Section 4.1 provides further details on how we operationalize HBU variables.

[17] This violation can be formalized by extending our theoretical framework to include a spatial equilibrium condition for the supply and demand of real estate surface. If the market of new HBU properties is not perfectly separated from the one of 'old' properties, any demand shock to one market segment will propagate to the other segment, thereby creating a correlation between y_{it}^{*R} and y_{it}.

[18] Relying on historical data to instrument contemporaneous variables is not new in the economic literature. See, for example, Ciccone and Hall (1996).

4. Data and descriptive statistics

We use georeferenced transaction data on US commercial real estate properties from 2001 to 2018 provided by Real Capital Analytics (RCA). In our empirical analysis, we use the following groups of variables.

Model-based variables and hedonic characteristics The data set features all the main variables entering our theoretical framework, namely the property transaction price (P_{it}), the age of the building ($t - t_0$), its NOI (y_{it}), the capital intensity (S_{it}), and the size of the plot of land (L_{it}) on which the building is located. We complement these variables with hedonic characteristics that might influence the transaction price. These characteristics include the type of commercial building (residential, industrial, office, or retail), a quality index based on the building's physical characteristics, and the number of real estate units in the building.

Because NOI per unit of surface capacity is missing in approximately 70% of the cases, we impute such values as follows. For each property having a missing NOI, we first find the ten closest properties within a 5 km radius that are not being redeveloped, are built (sold) within ten (five) years as the target property, are of the same property type, and have non-missing NOI. To refine the quality of the imputation, we use market and property type-specific NOI indexes provided by RCA to correct the imputed NOIs when the year of sale of the nearby properties is different from the one of the target property. Next, we impute the missing NOI per surface unit using a weighted average of the NOI of these selected properties. The weights are set equal to the inverse of the distance to the target property and normalized to add up to 1. Note that in Section 5, we perform several robustness checks to verify the sensitivity of our results to such imputation and find that our results remain stable.

Market potential We also consider variables capturing the attractiveness of the local market in which the property is located, hereafter labeled 'market potential'. Specifically, we control for i) a walk-score index measuring the degree of access to the building without relying on the car or public transportation, ii) a dummy variable indicating whether street retail is possible, iii) a dummy indicating whether the building is subsidized, and iv) a dummy indicating whether the building is located in an opportunity zone.

Buyer and seller characteristics Buyer characteristics include our variable of interest, namely the investor's stated intention to acquire the real estate asset for immediate redevelopment (D_{it}^{Red}). To capture the idiosyncratic tastes of buyers and sellers, we control for i) the buyer/seller type of capitalization[19], ii) the geographic scope of the buyer/seller (local, national, continental, and global), iii) whether the buyer is foreign (dummy), iv) the type of deal between buyer and seller (appraised, approximate, confirmed, private, street talk), and v) whether the building owner resolved a situation of distress (dummy).

4.1. Measuring market signals

As described in Section 3, our identification strategy relies on two types of market signals. We define the first market signal as the (log of the) ratio of capital intensities $\frac{S_{it}^{*R}}{S_{it}}$, which we label as the *capital intensity gap.* We observe the denominator of this ratio, which corresponds to the property's current floor to area ratio. We measure the numerator – i.e., the capital intensity of the plot of land to its HBU – as the weighted average of the capital intensity of *nearby recently built* properties,

$$S_{it}^{*R} \approx \frac{1}{\#\{jl \in I(it)\}} \sum_{jl \in I(it)} w_{jl} S_{jl}, \tag{11}$$

where the set $I(it)$ contains the ten geographically closest properties to building i that were built *and* transacted within five years from time t.[20] The weights w_{jl} are defined as the inverse of the normalized distance between properties $jl \in I(it)$ and property it.[21] This measure is consistent with the view that investors attribute less importance to market signals coming from more distant properties. The definition of the set $I(it)$ allows us to reach a sufficient sample size of properties proxying the HBU capital intensity while remaining relevant for

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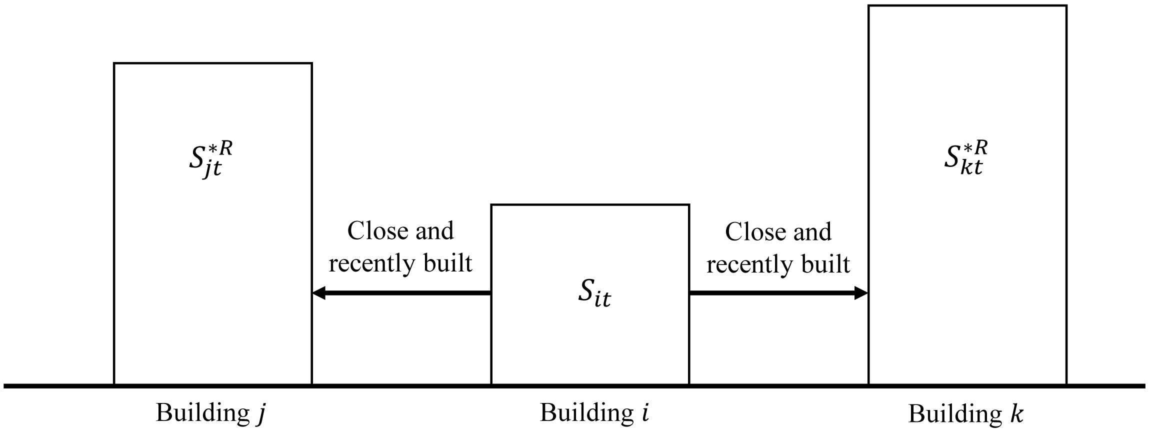
[19] Buyers and sellers are classified into about 20 types of capitalization. The most common categories are developers, equity funds, investment managers, REITs, and corporate investors.

[20] We justify the choice of a five-year interval as follows. First, given the low-frequency nature of transactions in commercial real estate, investors likely gather information on investment decisions not only in the same year in which they want to invest but also in the recent past. Second, the construction of commercial buildings may take several years. Therefore, at time t investors may be aware of market signals that will appear in transaction data only several years later.

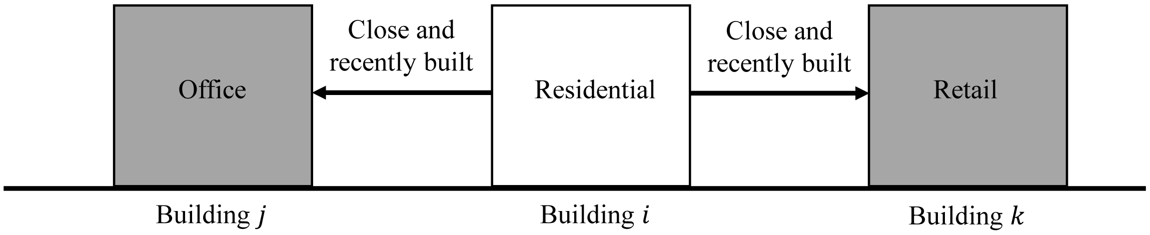
[21] Formally, $w_{jl} = \frac{\frac{1}{d_{jl}}}{\sum_{jl \in I(it)} \frac{1}{d_{jl}}}$, such that the sum of all weights w_{jl} in a set $I(it)$ equals 1.

Figure 1: Type of market signals

Panel A: Capital intensity gap



Panel B: Economic activity mismatch



the variable we want to instrument. Section 5.1 estimates the relationship between the probability of buy-to-redevelop investment strategies when market signals are measured at different distances from a given property to ensure that our market signals are not driven by distant properties.[22] Large values of the capital intensity gap instrument $z_{it}^{Gap} = \ln(S_{it}^{*R}/S_{it})$ indicate a large gap between the capital intensity of the existing property and nearby recently built ones, as illustrated in Panel A of Figure 1. Higher values of z_{it}^{Gap} are thus expected to positively correlate with a higher likelihood of redevelopment.

The second market signal is given by the index z_{it}^{Mism}, which captures the extent to which the *type* of revenue-generating activity of a given commercial building (residential, industrial, office, or retail) *does not match* the one of *recently built nearby properties.* Specifically, we

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[22] Note that the average distance to the ten geographically closest properties that were built and transacted within five years is less than 3.5 km.

compute

$$z_{it}^{Mism} = \frac{\#\{Type_{jl} \neq Type_{it}, jl \in I(it)\}}{\#\{jl \in I(it)\}}, \tag{12}$$

where the definition of the the $I(it)$ is as before. A value of zero (one) indicates that all (none) of the nearby recently built properties are of the same type of the considered building.[23] A higher index value thus implies a stronger building usage obsolescence (see Panel B of Figure 1) and should be associated with a higher probability of redevelopment. However, our economic activity mismatch market signal might also be complementary, e.g., a retail property might benefit from recently nearby built office space. This would weaken this market signal.

4.2. Descriptives

Table 1 summarizes the main model-based determinants of transaction prices for redevelopment properties (Panel A) and non-redevelopment properties (Panel B).[24] We also include summary statistics for our two instrumental variables (market signals).

Comparing Panel A and B of Table 1 reveals some differences between redevelopment properties and non-redevelopment properties. On average, the transaction price of redevelopment properties tends to be higher than that of the non-redevelopment properties, as they usually possess a higher capital intensity and generate a higher income per square meter. Unsurprisingly, redevelopment properties are older than non-redevelopment ones. Interestingly, the land surface on which properties are located is similar for redevelopment and non-redevelopment properties. Finally, we observe that residential properties tend to be underrepresented among redevelopment properties, whereas the opposite is true for office and retail properties. These differences, however, are statistically insignificant due to large sample variances. The similarity in the distribution of model-based variables is further confirmed when considering their distribution's 1^{st} and 9^{th} deciles, which are similar between

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[23] Our data set indicates the property's primary use and if the property has street retail. Only around 5% of the properties in our sample have retail space. Unfortunately, the data does contain more detailed data on property use. To deal with mixed-used buildings, we control for the retail space dummy in our analysis.

[24] Due to space constraints, we present only the main model-based variables. Descriptive statistics for the other controls are available in Appendix B

Table 1: **Transactions of US commercial properties from 2001 to 2018**

	Mean	SD	10%	90%
Panel A: Redevelopment properties (3,133 obs.)				
Price (1000 USD)	21,196	49,548	2,826	44,170
Age (Years)	53	29	18	96
NOI (USD/m2)	217	401	53	392
FAR	1.953	3.243	0.224	5.094
Land (m2)	21,519	54,095	523	55,078
Capital intensity gap	2.551	2.229	0.547	5.829
Economic activity mism.	0.705	0.251	0.300	1.000
Property types	Residential	Industrial	Office	Retail
	15.13 %	19.69 %	35.17%	30%
Panel B: Non-redevelopment properties (80,477 obs.)				
Price (1000 USD)	15,679	47,269	2,550	32,695
Age (Years)	37	28	6	85
NOI (USD/m2)	152	159	47	282
FAR	1.210	2.122	0.212	3.231
Land (m2)	19,832	35,525	707	52,609
Capital intensity gap	1.715	1.546	0.515	3.461
Economic activity mism.	0.641	0.274	0.200	1.000
Property types	Residential	Industrial	Office	Retail
	38.95 %	17.33 %	21.15%	22.57%

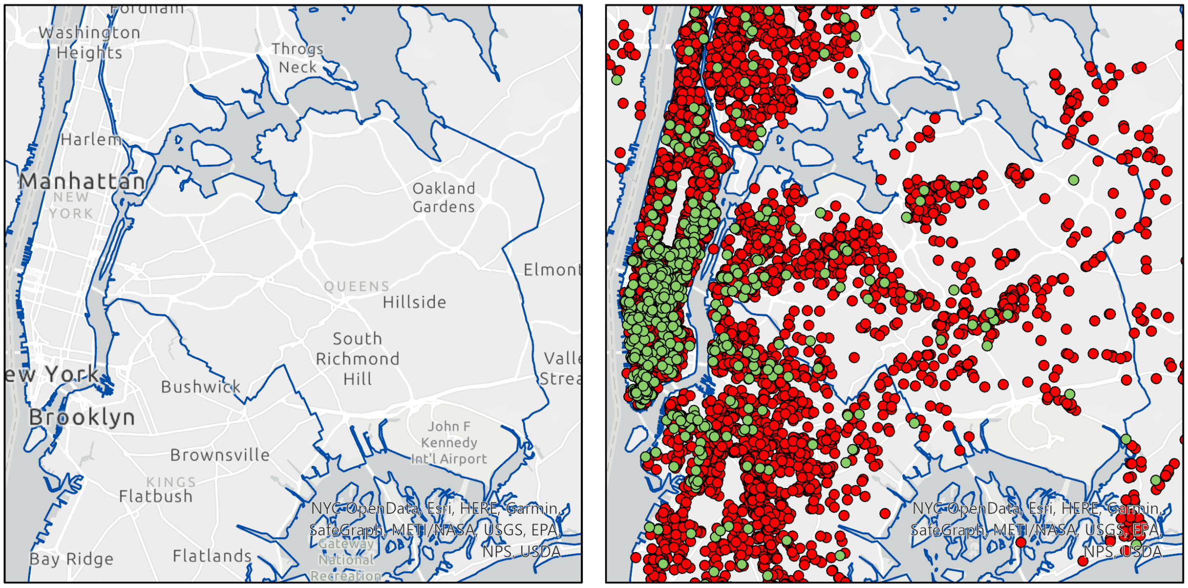
Notes: SD is the standard deviation, 10% is the 10th quantile and 90% is the 90th quantile. NOI is the Net Operating Income per surface unit of the property. FAR is the Floor Area Ratio, corresponding to the total building surface divided by the land surface. See Section 4.1 for a definition of the capital intensity gap and economic activity mismatch instruments.

redevelopment and non-redevelopment properties.

The high standard deviation of the observed variables is due, in part, to the fact that transacted commercial properties are scattered across the US territory, implying a great dispersion in the value of market fundamentals. However, a clearer pattern emerges when zooming in at a more local level. Figure 2 illustrates transaction patterns of commercial properties in the case of three counties (New York, Kings, and Queens) belonging to the New York metropolitan area. We focus on the New York metropolitan area because it is a worldwide renowned investment hub targeted by commercial real estate investors. We observe similar patterns in other metropolitan areas.

As it can be seen, institutional investors predominantly decide to invest close to CBDs,

Figure 2: Spatial distribution of commercial real estate transactions – 2001-2018



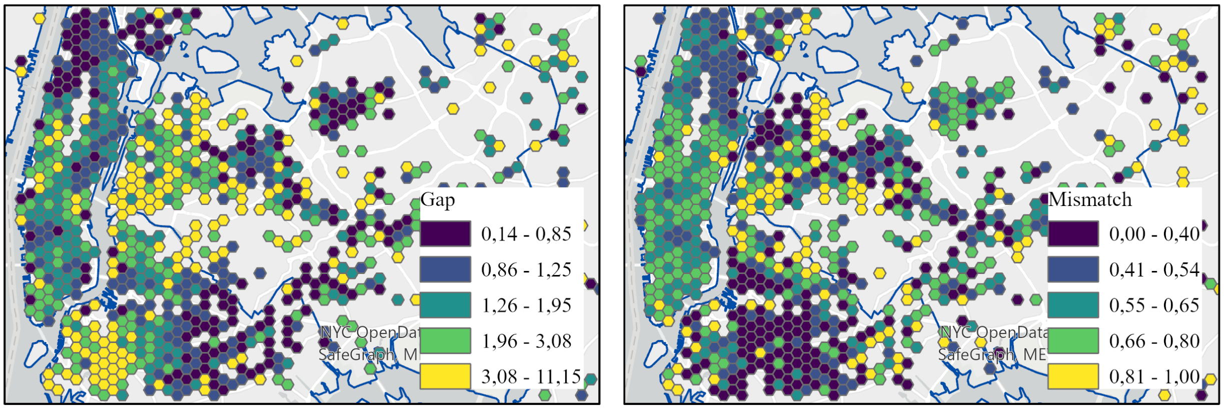
Notes: The maps show part of the New York metropolitan area. The left panel provides location labels and county borders (in blue) for reference purposes. Green dots in the right panel represent redevelopment properties, whereas red dots represent non-redevelopment properties.

such as Manhattan. This is even more evident in the case of investments carried out for redevelopment purposes. The reasons for this spatial concentration are multi-faceted and depend, of course, on many local market fundamentals. Higher transaction prices, NOI, and capital intensity of redevelopment properties thus, arise because redevelopment properties are usually traded closer to the central business district of the metropolitan area than non-redevelopment properties. This centrality also implies that redevelopment properties are older, as central areas are historically developed first to accommodate stronger demand pressures.

Table 1 also hints at differences in market signals between redevelopment and non-redevelopment properties. On average, properties purchased for redevelopment tend to display a larger capital intensity gap and a greater economic activity mismatch. Overall, this fact provides stylized evidence that these two market signals might predict whether investors acquire property for redevelopment.

To further deepen our investigation of local spatial dynamics, Figure 3 illustrates the spatial distribution of the two types of market signals in the case of the New York metropolitan area. Specifically, Panel A and B of Figure 3 show the quintile distribution of the capital

Figure 3: Spatial distribution of market signals – 2001-2018



Notes: The maps show part of the New York metropolitan area. The left panel shows the quintile distribution of the capital intensity gap. The right panel shows the quintile distribution of economic activity mismatch.

intensity gap and economic activity mismatch, respectively. Zooming in at a more local level provides a few additional insights.

There is a good overlap with redevelopment decisions depicted in Figure 2 and upper quintile values of capital intensity gap and economic activity mismatch. Places where *both* market signals tend to have values in the upper quintiles, such as Manhattan, the west area of Queens, and the northern region of Kings, seem to match particularly well with the location of investments for redevelopment purposes. Interestingly, in some other areas, the two signals seem to act in a complementary way. For example, the Brooklyn area is not characterized by a high economic activity mismatch, whereas the capital intensity gap displays values in the upper quintile range. Conversely, redevelopment decisions to the immediate west of the Oakland Gardens are more consistent with an economic activity mismatch than a capital intensity gap. These two facts suggest that i) each signal might be a good predictor of redevelopment decisions, and ii) it might be relevant to consider the two signals jointly.

5. Results

We start by analyzing the extent to which market signals trigger buy-to-redevelop investment strategies. Furthermore, we provide novel insights into the spatial relationship between the geographic proximity of market signals and investors' redevelopment decisions. Next, we provide evidence on the importance of reverse causality when estimating real option values. Specifically, we illustrate that buy-to-redevelop strategies are associated with higher investment risk, which in turn might decrease the investors' willingness to pay to acquire more expensive properties for redevelopment purposes. We then estimate the intrinsic value that investors attach to redevelopment, investigating whether differences exist across/within metropolitan areas and over time. We conclude by performing several robustness checks for our main estimates.

5.1. Relevance of market signals

We quantify the link between market signals – as given by the capital intensity gap and economic activity mismatch – and the likelihood that investors purchase a property for subsequent redevelopment. This step of the empirical analysis represents the 1st stage of the 3SLS procedure outlined in Section 5.3. Therefore, the focus here is more on the predictive power of market signals rather than on endogeneity issues related to the valuation of buy-to-redevelop investment strategies.

Table 2 illustrates the estimation results for the determinants of redevelopment formulated in the probit regression model (8). As one of the main goals is to gain insights into the determinants behind the computation of the predicted probabilities $\hat{D}^{Red}$ used to instrument the intent to redevelop D^{Red}, we include the same set of variables that we use to estimate the intrinsic value of the option to redevelop. In particular, the determinants of buy-to-redevelop investment strategies are divided into market signals and model controls suggested by the valuation framework.

Columns 1 to 5 in Panel A of Table 2 show the market signals estimated coefficients when progressively controlling for market potential and buyer/seller characteristics, while Panel B shows the corresponding Average Marginal Effect (AME) for the two types of market signals. To rule out confounding factors stemming from differences in building quality, macroeconomic dynamics, and time-invariant spatial differences between real estate markets, we always control for a property's hedonic characteristics, as well as transaction year and county fixed effects.

Panel A of Table 2 shows that a stronger capital intensity gap and a higher economic

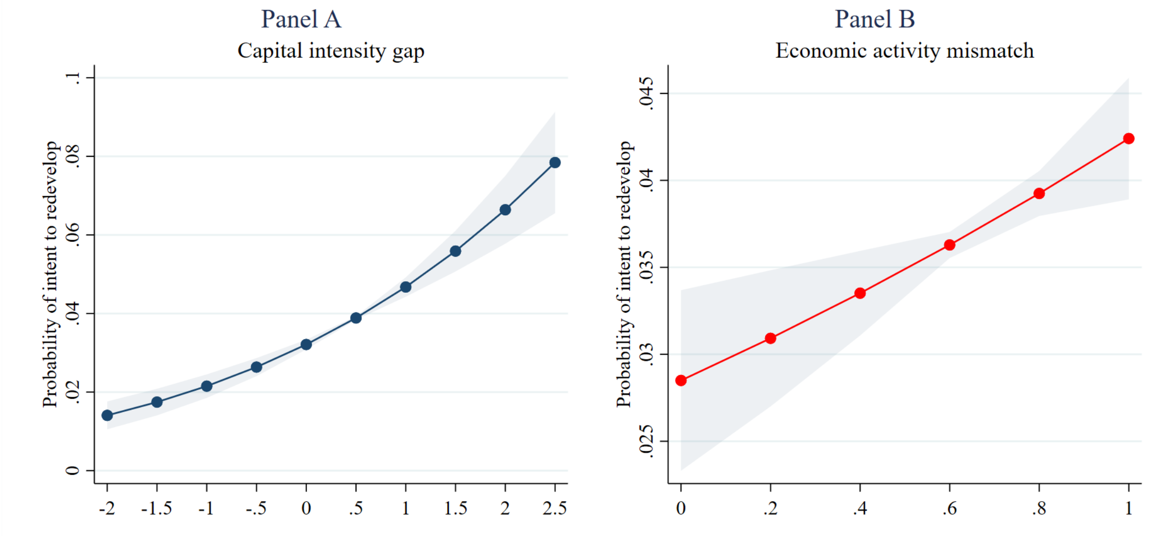
Table 2: **Determinants of the investors' intent to redevelop**

Panel A: Dependent variable: Redevelopment dummy (D^{Red}) - 1st stage estimates					
	(1)	(2)	(3)	(4)	(5)
Market signals					
Capital intensity gap	0.273***	0.210***	0.210***		0.205***
	(0.025)	(0.024)	(0.025)		(0.025)
Economic activity mism.	0.284***	0.247***		0.240***	0.214***
	(0.066)	(0.072)		(0.075)	(0.072)
Model controls					
Age	0.113***	0.098***	0.096***	0.104***	0.095***
	(0.010)	(0.009)	(0.009)	(0.010)	(0.009)
Log-NOI	0.041*	0.036	0.025	0.044*	0.029
	(0.022)	(0.024)	(0.024)	(0.025)	(0.023)
Log-FAR	0.338***	0.268***	0.251**	0.066	0.255**
	(0.099)	(0.100)	(0.104)	(0.096)	(0.101)
Log-Land	0.254***	0.350***	0.318***	0.266***	0.320***
	(0.097)	(0.097)	(0.101)	(0.098)	(0.098)
Year FE	Yes	Yes	Yes	Yes	Yes
County FE	Yes	Yes	Yes	Yes	Yes
Hedonic char.	Yes	Yes	Yes	Yes	Yes
Market potential	No	Yes	Yes	Yes	Yes
Buyer/seller char.	No	No	Yes	Yes	Yes
Observations	83,610	83,610	83,610	83,610	83,610
AIC	23,195	22,862	22,125	22,277	22,094
Panel B: Average marginal effect of market signals					
Capital intensity gap	0.020***	0.015***	0.014***		0.014***
	(0.002)	(0.002)	(0.002)		(0.002)
Economic activity mism.	0.020***	0.018***		0.016***	0.015***
	(0.005)	(0.005)		(0.005)	(0.005)

Notes: Clustered standard errors at the county level in parentheses $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$. Estimation is carried out using a probit model. The period of analysis is 2001-2018. A constant term is included in all specifications. Age is measured in decades. NOI is the Net Operating Income per surface unit of the property. FAR is the Floor Area Ratio, corresponding to the total building surface divided by the land surface. See Section 4 for the list of variables included as other hedonic characteristics, market potential, and buyer/seller characteristics. See Section 4.1 for a definition of capital intensity gap and economic activity mismatch.

activity mismatch are associated with a higher likelihood of investing in the property for redevelopment. The estimated coefficients of the two market signals remain stable across specifications and are highly significant. When we use the two market signals individually and include the full set of controls (Columns 3 and 4 of Table 2), the magnitude of their coefficients is very similar and not statistically different from those obtained when using the two signals simultaneously (Column 5 of Table 2). This invariance of the coefficients

Figure 4: Market signals and investors' intent to redevelop



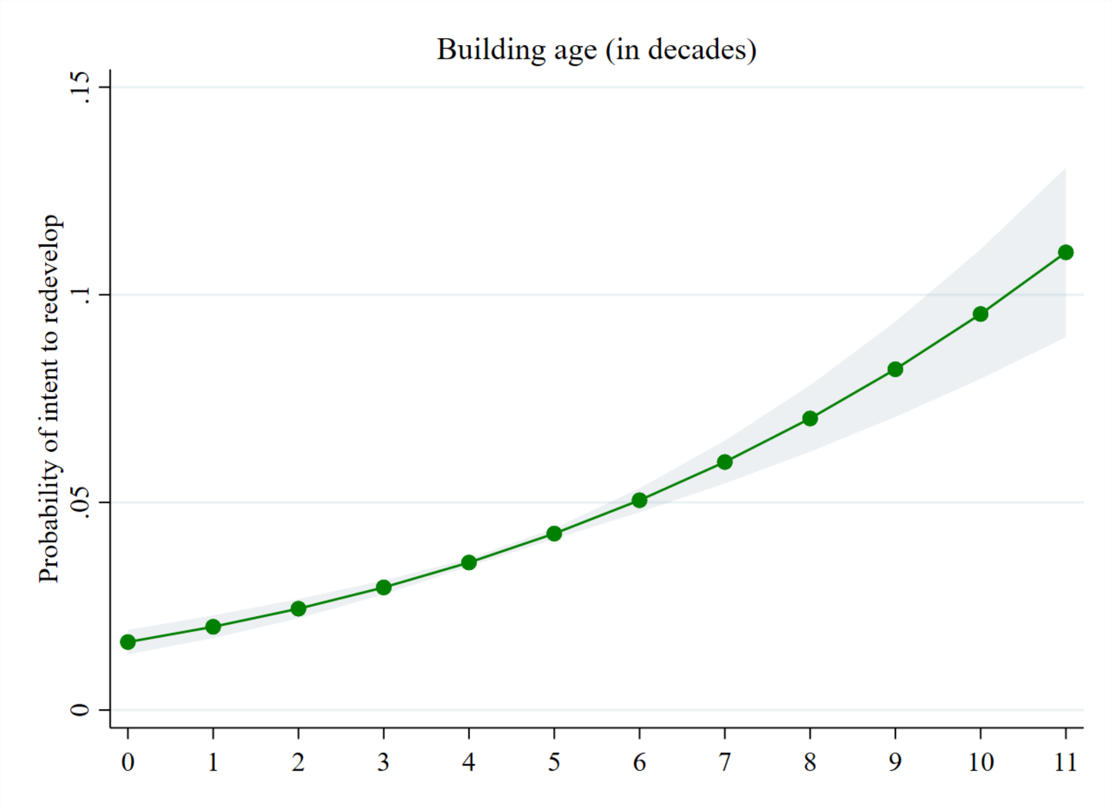
Notes: Standard deviations of predicted probabilities are computed using the delta method. The period of analysis is 2001-2018. The market signals' range of values corresponds to the one observed in the regression sample. See Section 4.1 for a formal definition of capital intensity gap and economic activity mismatch.

confirms the stylized fact illustrated in Figure 3 that capital intensity gaps and economic activity mismatch are strong *orthogonal* predictors of redevelopment investment strategies.

In line with the existing literature (Clapp and Salavei, 2010; Clapp et al., 2012), the age coefficient is positive, with older buildings having a higher probability of being purchased for redevelopment. The estimated age coefficient is stable across specifications and statistically significant. Interestingly, the magnitude of the coefficients of the two market signals exceeds the one of building age (measured in decades), suggesting that these variables might be at least as influential for redevelopment decisions as building age for common in-sample values. To verify this proposition, we next investigate AMEs.

The capital intensity gap AME – which, as reported in Column 5 of Table 2, equals 1.4 percentage points – is very close to the one for the type of economic activity mismatch. To better assess the magnitude of each market signal on the investors' intent to redevelop, in Figure 4, we plot the predicted probability of redevelopment ($P(D^{Red}) = 1$) against the values taken by the signals z^{Gap} and z^{Mism} in the regression sample. As can be seen, higher values of both signals unequivocally are associated with higher probabilities of buy-to-redevelop investment strategies. In the case of the signal z^{Gap} , a given building that is

Figure 5: Capital depreciation and investors' intent to redevelop



Notes: Standard deviations of predicted probabilities are computed using the delta method. The period of analysis is 2001-2018. The building age range of values corresponds to the one observed in the regression sample.

not subject to capital intensity gap ($z^{Gap} = \ln 1 = 0$) has, ceteris paribus, approximately a three percent probability of redevelopment. If the same building were located in a market where HBU properties have a capital intensity that is, on average, about 12 times bigger than the one of the observed building ($z^S = \ln 12 \approx 2.5$), its probability of redevelopment would go up to almost eight percent. In other words, the probability of investing in the property for redevelopment increases by 166% in relative terms.[25] A building for which investors' decisions do not signal an economic activity mismatch ($z^{Type} = 0$) has, ceteris paribus, a probability of redevelopment of about 2.8 percent. If the same building were located in a market where properties are all built for a different type of economic activity ($z^{Type} = 1$), its probability of redevelopment would increase approximately by 4.2 percent,

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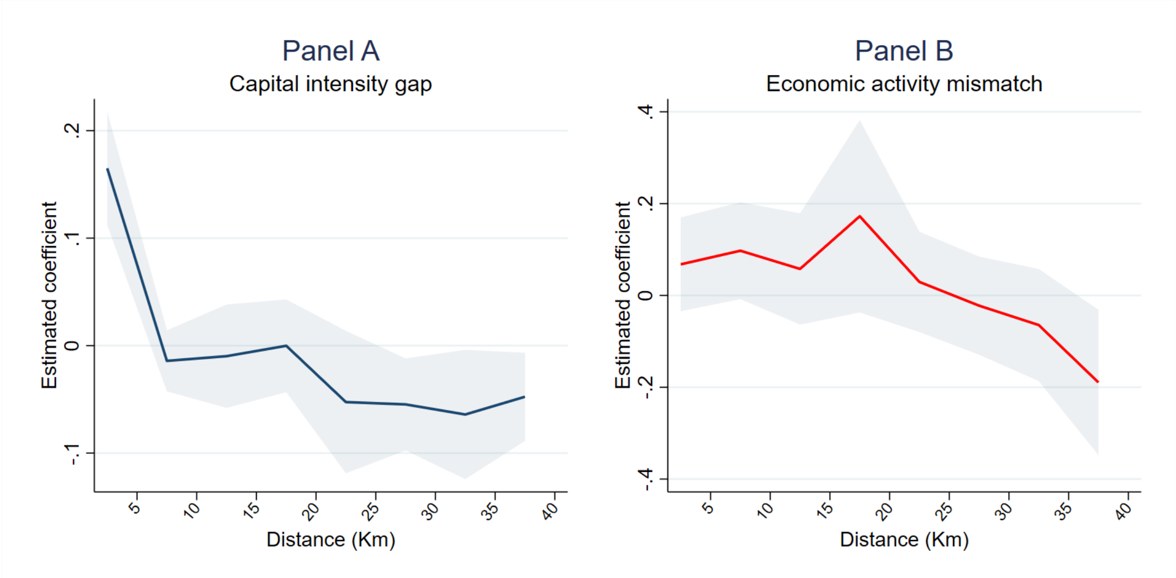
[25] Despite being large, a capital intensity ratio equal to 12 is not unrealistic. For example, if the existing property has a FAR=1 – which might be the case for several low-rise buildings – and HBU properties have a FAR=12 – which is common in mid and high-rise buildings – we obtain such a capital intensity ratio.

Figure 6: Spatial decay of market signals



Notes: Distance-specific coefficients are estimated using equation (13). Shaded areas correspond to 90% confidence intervals computed using clustered standard errors at the county level. Distance-specific coefficients are associated to the corresponding distance interval centroid. The period of analysis is 2001-2018.

implying a relative probability increase of 50%. Therefore, despite the AMEs of the two market signals being both significant and of similar magnitude, the capital intensity gap signal plays a bigger role than the type of economic activity mismatch in leading investors to purchase a property for redevelopment. This is probably because the economic activity mismatch market signal might also be complementary, e.g., when a retail property benefits from nearby recently built office space.

A comparison with the predicted probability of redevelopment according to building age illustrated in Figure 5 reveals that, in absolute terms, the combined effect of both market signals might spur buy-to-redevelop investment strategies at least as much as capital depreciation. Interestingly, both the capital intensity gap and capital depreciation display a convex relationship with the likelihood of redevelopment.

These results provide empirical evidence for the theoretical findings by Grenadier (1996), Grenadier (1999), Grenadier (2002), and Grenadier and Malenko (2011), showing not only that localized market signals indeed act as an information externality but also that their effect on investors' decisions is large in magnitude.

A legitimate question is whether the relevance of market signals is purely local in nature. Specifically, the previous results have been derived by computing signals using geographically close investment decisions. Are market signals when too distant from a given location? This question cannot be answered based on theoretical considerations and requires an empirical analysis. We thus estimate the relationship between the probability of buy-to-redevelop investment strategies when market signals are measured at different distances from a given property. Specifically, we estimate the following alternative specification of the probit model (8)

$$Pr(D_{it}^{Red} = 1|X_{it}, Z_{it}) = \Phi\left(\theta_0 + \theta_1 X_{it} + \sum_k \beta^{[d_k,d_{k+1}[} Z_{it}^{[d_k,d_{k+1}]}\right), \tag{13}$$

where $Z_{it}^{[d_k,d_{k+1}]}$ denotes the average value of a either the capital intensity gap ratio or index of economic activity mismatch in the distance interval $[d_k, d_{k+1}]$ from property i transacted at time t. The other variables are defined as before. The coefficients $\beta^{[d_k,d_{k+1}]}$, which correspond to the influence of an market signal at a given distance interval from a transacted property, are the parameters of interest.

Figure 6 plots the estimated coefficients $\beta^{[d_k,d_{k+1}[}$ together with their 90% confidence intervals against the distance intervals $[d_k, d_{k+1}]$, where $[d_k, d_{k+1}] = [k\cdot 5\text{km}, (k+1)\cdot 5\text{km}]$, $k = 0, ..., 7$.[26] As it can be seen, the positive value of the coefficients of both market signals tends to decay with distance, turning negative for longer distances. We observe several differences in the behavior of the two signals.

The effect of the capital intensity gap signal on buy-to-redevelop investment decisions is positive and strong for small ($\leq$ 5km) distances close to a given property. The magnitude of the effect sharply decreases with distance and is close to zero and statistically insignif-

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[26] Note that the interval width of 5km and the maximal distance from a given transaction (40km) are chosen to achieve a balance between the spatial scale of the analysis and statistical significance. Overall, estimated distance-specific coefficients lose statistical significance with respect to those estimated using z^{Gap} and z^{Mism} without distinguishing for distance. This is because breaking down market signals according to distance is statistically demanding along several dimensions. First, the sample size is about 10% smaller, as we do not observe an market signal in the defined distance intervals for all transacted properties. Second, the fact that we aggregate market signals within a distance interval reduces the signal variance in the regression sample. Third, the values of the market signals according to different distances tend to be positively correlated with each other, thereby inflating standard errors.

icant over medium distances (5km – 20km). The effect then turns negative and becomes statistically significant again for long distances (≥ 25km). The effect of informational externalities provided by the economic activity mismatch is positive but more stable for short and medium distances (0km – 20km) and only starts to decrease – becoming negative – for longer distances (≥ 25km).

These results suggest that informational externalities do not necessarily need to be localized in the proximity of a given property to be considered informative by investors. On the contrary, the negative effect of capital intensity gap and type of economic activity for larger distances likely signals to investors a spatial displacement of market activity toward more distant areas, discouraging them from purchasing a property for redevelopment. The fact that investors pay attention to more distance market signals – and not only to localized ones – seems reasonable given that we investigate the behavior of institutional investors, who typically consider investment opportunities over large geographies.

5.2. Investing to redevelop, leverage, and risk

When empirically estimating the intrinsic value of real options, an important aspect is the risk associated with such investment decisions. Failing to do so ignores potential endogeneity issues arising from the reverse causality between an asset market value and the likelihood of investing in the asset to exercise a real option. All else equal, if investing in a property to drastically modify its characteristics is riskier than investing in the property without further modifying its current structure, investors might be reluctant to acquire pricier properties. More formally, the observed redevelopment dummy D_{it}^{Red} in (6) might be negatively related to the transaction P_{it}, which would bias the estimation of β downward. This section provides evidence that such reverse causation is likely to occur.

Why are 'buy-to-redevelop' investment strategies riskier than 'leave-as-is' ones? We argue that this is due to the relationship between redevelopment and financial leverage. Conditional on their values, properties purchased for redevelopment tend to be more leveraged, amplifying downside risk. Construction loans – which in redevelopment projects are subscribed to finance the demolition of the old building and the construction of the new property – do not cover land acquisition costs. Ceteris paribus, the average LTV of a redevelopment should thus be about 20% higher to cover land acquisition costs, as explained in Bokhari and Geltner (2018).

Redevelopments are also riskier because demolition and construction costs are contractually fixed upfront, and cash flows generated by the new development are comparatively more uncertain. The time interval between the start of the redevelopment project and the date from which the project starts to generate a stable flow of revenue can span up to 5 years, depending on the size and complexity of the project (Geltner et al., 2014). Given this higher risk, financial institutions tend to be more cautious in financing redevelopment projects, spreading the loan over several periods and shortening the loan duration. This shorter loan duration allows financial institutions to verify that specific criteria related to the different phases of the redevelopment project – such as demolition, foundational work, etc. – are met before proceeding to provide the next part of the loan. Importantly, the construction loan has to be paid off in full before the property is put on sale or a standard investment loan is entered.

To provide empirical evidence supporting the above stylized facts documented in the literature, we investigate the link between redevelopment investment decisions and three loan characteristics discussed above, namely loan amount, LTV, and loan duration.[27] Table 3 shows the results when we include the full set of controls used in Columns 3-5 of Table 2 .

The empirical findings support all three stylized facts discussed above. Specifically, we find that investors that purchase a commercial property for redevelopment i) tend to borrow a larger amount of capital (Column 1), ii) have a capital stack that is about 27% more leveraged (Column 2), and subscribe to loans whose duration is about half as short as non-redevelopment projects (Column 3). Given the higher leverage and corresponding risk amplification, it thus seems plausible to assume that investors are more reluctant to invest in pricier properties for redevelopment purposes.

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[27] To this end, we merge data on loan characteristics provided by RCA with transaction data on commercial properties used in our main regression sample. Because information on loan characteristics is available only for a smaller sample of properties, the sample size is reduced.

Table 3: **Difference in loan characteristics of redevelopment projects**

	(1)	(2)	(3)
	Log loan amount	Log loan LTV	Log loan termination
Redevelopment (D^{Red})	0.269***	0.269***	-0.467***
	(0.014)	(0.013)	(0.038)
Age	0.005***	-0.003***	-0.021***
	(0.001)	(0.001)	(0.003)
Log-NOI	0.486***	-0.011***	-0.006
	(0.004)	(0.004)	(0.010)
Log-FAR	0.849***	0.007**	-0.077***
	(0.004)	(0.003)	(0.007)
Log-land area	0.873***	0.030***	-0.074***
	(0.003)	(0.003)	(0.006)
Year FE	Yes	Yes	Yes
County FE	Yes	Yes	Yes
Hedonic char.	Yes	Yes	Yes
Market potential	Yes	Yes	Yes
Buyer/seller char.	Yes	Yes	Yes
Observations	52,299	24,229	17,558

Notes: Clustered standard errors at the county level in parentheses $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$. The period of analysis is 2001-2018. A constant term is included in all specifications. Loan amount is measured in million dollars. Loan termination is measured in months. Age is measured in decades. NOI is the Net Operating Income per surface unit of the property. FAR is the Floor Area Ratio, corresponding to the total building surface divided by the land surface. See Section 4 for the list of variables included as other hedonic characteristics, market potential, and buyer/seller characteristics.

5.3. The value of market signals via redevelopment options

We now turn to the estimation of the intrinsic value of purchasing a property for redevelopment The baseline specification is the one suggested by the hedonic equation (6), to which we progressively add market potential controls and buyer/ seller characteristics.

To assess the importance of reverse causality bias, in Column 1 of Table 4 (Panel A), we report an OLS estimate of β. We find that the OLS estimate of the redevelopment intrinsic option value is extremely close to zero in magnitude and statistically insignificant. As discussed in Section 5.2, this small magnitude is likely due to an endogeneity bias arising from reverse causality.[28] In Columns 2 to 4 of Table 4 (Panel A), we thus report 3rd stage

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[28] To underlay this downward bias, in Appendix D, we regress log-prices directly on our instruments, including the full set of controls. Our primary instrument, the capital intensity gap, positively and significantly affects the transaction price.

Table 4: **Intrinsic redevelopment option value**

Panel A: Dependent variable: Log-price				
	(1)	(2)	(3)	(4)
	OLS	3rd stage estimates		
Redevelopment (D^{Red})	-0.005	0.507***	0.374**	0.308***
	(0.025)	(0.176)	(0.160)	(0.115)
Age	-0.002	-0.008***	-0.008***	-0.007***
	(0.002)	(0.003)	(0.003)	(0.002)
Log-NOI	0.167***	0.164***	0.132***	0.133***
	(0.009)	(0.009)	(0.007)	(0.007)
Log-FAR	0.086**	0.079*	0.080**	0.093**
	(0.044)	(0.044)	(0.038)	(0.037)
Log-land area	0.065	0.056	0.069*	0.087**
	(0.042)	(0.042)	(0.038)	(0.037)
Kleibergen-Paap F	-	316.37	418.05	301.23
Panel B: Dependent variable: Redevelopment dummy – 2nd stage estimates				
Predicted redev. pot.		1.101***	1.215***	1.171***
		(0.062)	(0.059)	(0.067)
Year FE	Yes	Yes	Yes	Yes
County FE	Yes	Yes	Yes	Yes
Hedonic char.	Yes	Yes	Yes	Yes
Market potential	No	No	Yes	Yes
Buyer/seller char.	No	No	No	Yes
Observations	83,610	83,610	83,610	83,610

Notes: Clustered standard errors at the county level in parentheses $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$. The period of analysis is 2001-2018. A constant term is included in all specifications. Age is measured in decades. NOI is the Net Operating Income per surface unit of the property. FAR is the Floor Area Ratio, corresponding to the total building surface divided by the land surface. See Section 4 for the list of variables included as other hedonic characteristics, market potential, and buyer/seller characteristics. See Section 4.1 for a definition of capital intensity gap and economic activity mismatch.

estimates of β obtained when estimating equation (10) according to the 3SLS procedure described in Section 3.2. Panel B of Table 4 shows the corresponding second-stage results when estimating equation (9).[29]

Third-stage estimates show a positive and statistically significant value for the intrinsic redevelopment option value. The option values reported in Columns 2 to 4 in Panel A of Table 4 are relatively stable in magnitude across specifications and always about 1.6 standard

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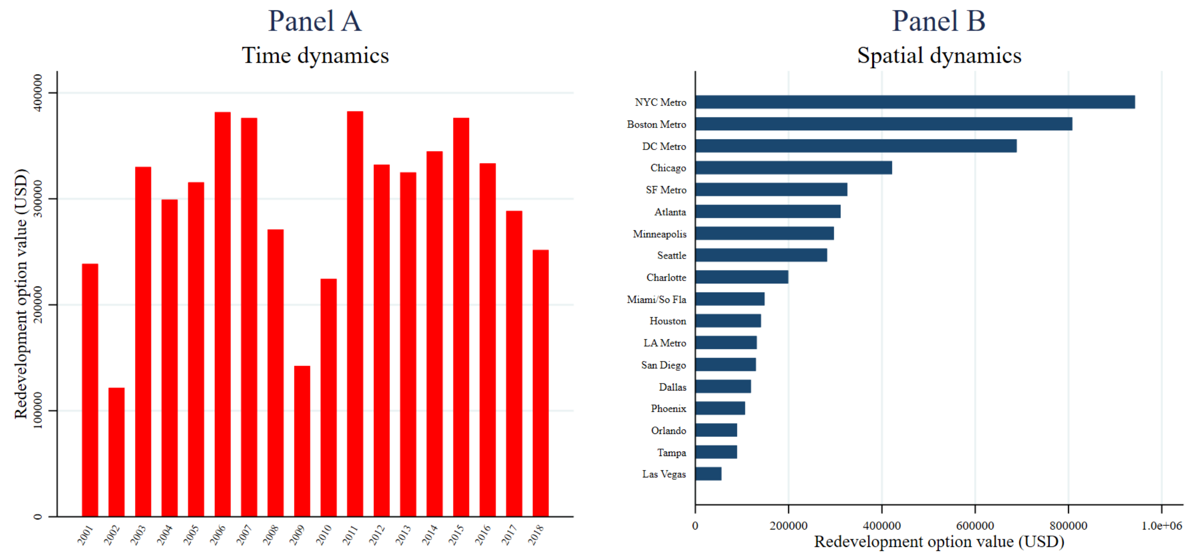
[29] First-stage results of specifications reported in Columns 2, 3, and 4 of Table 4 are illustrated in Columns 1, 2, and 5 of Table 2, respectively.

Figure 7: Redevelopment Option Value in US major urban areas



Notes: US urban areas are defined according to RCA definition of metropolitan areas. Major urban area consist in urban areas in which we observe at least 1'000 transactions of commercial properties over the period of our analysis (2001-2018).

deviations from each other. This stability adds further credibility to our causal interpretation of the option value associated with redevelopment. Our most conservative estimate, which we obtain when using the full set of controls in Column 4, indicates a redevelopment option value of approximately 30%. Parameter estimates of the model-based controls also have the expected sign, and their magnitude hardly changes across specifications. As predicted by the theoretical framework, building age has a negative impact on the transaction price, whereas it was associated with a positive intention to redevelop. In contrast, NOI, FAR, and land area all have the expected positive impact on the transaction price.

Our results show that investors are willing, ceteris paribus, to pay a 30% higher price for buildings that they deem worthy of redevelopment in the near future, according to the market signals. According to second-stage results reported in Panel B of Table 4, the redevelopment potential – denoted by $\hat{D}^{Red}$ in (9) – is positively and significantly related to the intention to redevelop redevelopment D^{Red}. This strong relationship is reflected in extremely high Kleibergen-Paap statistics reported in Panel A of Table 4, which are well above the conventional rule-of-thumb threshold of 10 used in standard 2SLS procedures.

5.4. The value of market signals over time and across space

In the previous section, we estimate the average value of market signals that affect a property value via the redevelopment option attached to it. This value represents the option value that an investor attributes to a property when he deems that it's optimal to invest in it to exercise the option to redevelop immediately. As explained in Section 3, however, properties *not* purchased for redevelopment also possess an option value. Simply it has not reached its optimal value yet.[30] The transaction price differential due to the intrinsic value to redevelop thus arises from the difference in redevelopment potential r^{Pot} between properties purchased for immediate redevelopment and those not.

An interesting question is to quantify the average redevelopment potential value associated with market signals across *all* properties, not just those purchased for redevelopment. This allows us to determine, for example, how observed market signals affect aggregate market price dynamics in specific time periods and/or across different markets.

We proceed as follows. According to the 3$^{\text{rd}}$ stage equation (10), an unbiased price prediction $\hat{P}_{it}$ of P_{it} is given by

$$\hat{P}_{it} = \exp\left(E(\ln P_{it}|, X_{it}) + \frac{1}{2}\hat{\sigma}^2\right)\exp(\hat{\beta}\hat{\hat{D}}^{Red}_{it}) = \hat{P}^N_{it} exp(\hat{\beta}\hat{\hat{D}}^{Red}_{it}), \tag{14}$$

where $\hat{P}^N_{it}$ is the predicted property value when the property is never redeveloped. The term $\frac{1}{2}\hat{\sigma}^2$ is a standard adjustment component, which depends on the estimated error term's variance $\hat{\sigma}^2$, used to obtain unbiased predictions of $\hat{P}^N_{it}$. We can re-write the estimated price as $\hat{P}_{it} = \hat{P}^N_{it}(1 + s_{it}) = \hat{P}^N_{it} + \hat{P}^N_{it}s_{it}$, where $s_{it} = \exp(\hat{\beta}\hat{\hat{D}}^{Red}_{it}) - 1$. The term $\hat{P}^N_{it}s_{it}$ represents the component of the property value that arises from the the redevelopment option, expressed as a shifter of the property value if it were never redeveloped.[31]

We use the above decomposition of the predicted price to compute the average predicted

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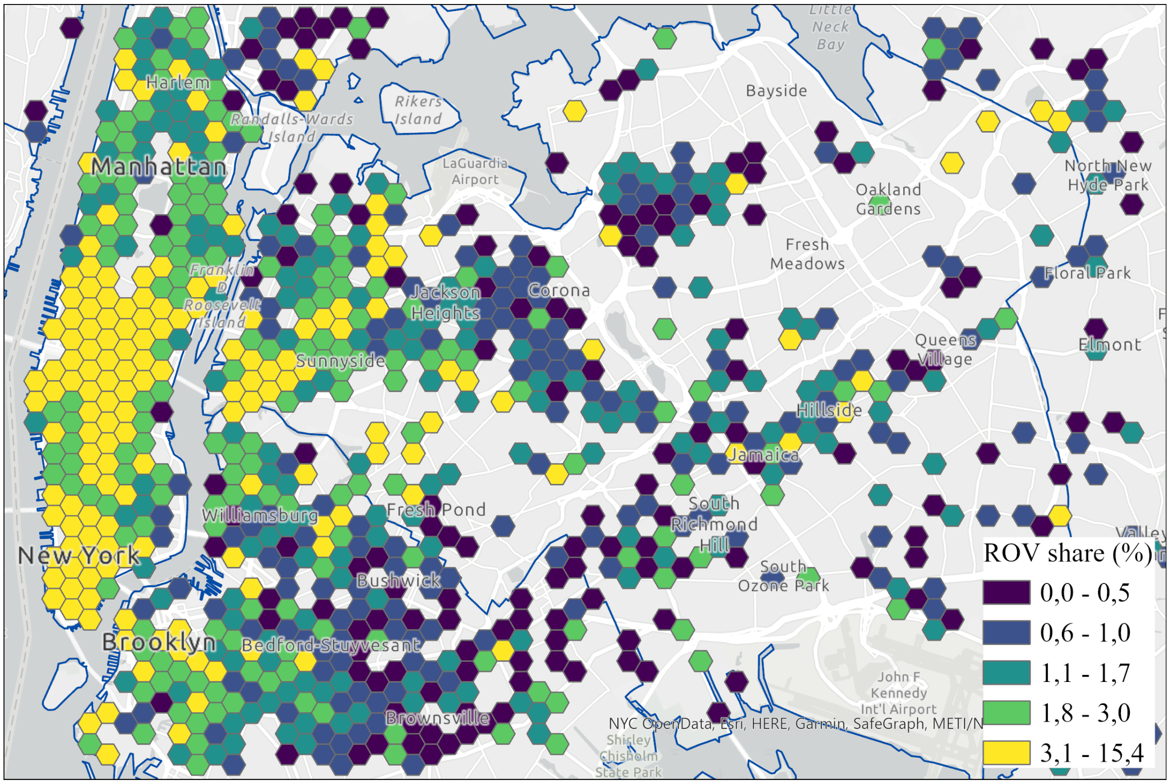
[30] Even recently-built properties might have some slight redevelopment potential in the context of quickly changing market fundamentals or unanticipated changes in zoning regulations. Still, such changes are usually not strong enough to justify their redevelopment in the near future.

[31] See Section Appendix C for further details on the estimation procedure.

Figure 8: Redevelopment option value as share of transaction price – NY metro area



Notes: The figure shows part of the NY metropolitan area. The period of analysis is 2001-2018.

option value over specific sub-samples, i.e., we average $\hat{P}_{it}^{N} s_{it}$ over observations satisfying a given sample restriction. Panels A and B of Figure 7 show the average yearly option value (in USD) in US major urban areas and the average option value across such major US urban areas, respectively. As it can be seen, some notable patterns emerge. Panel A shows that the average option value displays strong cyclicality, with an apparent dip of the value to redevelop in the aftermath of the Great Financial Crisis and a subsequent rebound in 2011. Interestingly, from 2016 onward, the average real option value started declining again in major urban areas. This is in line with the decline in the MSCI Capital Liquidity Score.[32] As pointed out by van Dijk et al. (2020), a decline in liquidity while rising prices often presages the end of a period of rapid price growth. Panel B shows that the average option value markedly differs across major US urban areas, with superstar areas such as New York and Boston displaying much larger value than comparatively less attractive areas such as

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[32] The MSCI Capital Liquidity Score measures the depth and breadth of capital active in global real estate markets.

Tampa or Dallas.

To investigate how market signals build up in transaction prices via redevelopment option value at a finer scale level, in Figure 8 we illustrate the option value as a share of the transaction price – i.e., $\hat{P}_{it}^{N} s_{it}/P_{it}$ – for small contiguous neighborhoods in the NY metropolitan area. In general, the average option value as a share of the transaction price is below the estimated intrinsic value share of 30.8% of our baseline specification, as those properties for which redevelopment potential has not reached its maximum value yet are also included in the sample. Figure 8 shows considerable heterogeneity in average option value share across neighbors. Consistent with Figure 2, neighbors with strong redevelopment activity have higher relative values. This suggests that structural valuation models that impose the same parameters' values over large geographic areas – thus usually resulting in homogeneous option values – might strongly limit our understanding of option value dynamics across local markets.

5.5. Identification assumption robustness checks

We perform several robustness checks to verify the sensitivity of our redevelopment option value estimates. For space reasons, we only report robustness checks for our most conservative estimate reported in Column 4 (full set of controls) of Table 4. Table 5 summarizes these results.

County-level time trends. To address potential endogeneity issues arising from unobserved time trend differentials across local markets, we check the robustness of our results when partialling out county fixed effects interacted with year fixed effects. In particular, these interaction terms address omitted variable concerns in equation (6) regarding the investors' expectations and risk perceptions of local real estate markets, as these latter are unlikely to vary significantly within a given county in a given year. The estimate for the redevelopment option value (Column 1) is stable to the inclusion of county time trend differentials.[33]

Positive externalities. In our empirical approach, we assume that investors consider

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[33] Note that specific county-year fixed effects are not included whenever such a combination perfectly predicts redevelopment decisions.

Table 5: **Robustness: Intrinsic redevelopment option value**

Panel A: 3rd stage – Dependent variable: Log-price						
	(1)	(2)	(3)	(4)	(5)	(6)
Redevelopment (D^{Red})	0.365***	0.266**	0.309***	0.373***	0.261**	0.357***
	(0.116)	(0.116)	(0.112)	(0.107)	(0.115)	(0.123)
Age	-0.007***	-0.006***	-0.007***	-0.007***	-0.007***	-0.012***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.003)
Log-NOI	0.128***	0.132***	0.133***	0.132***	0.129***	
	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	
Log-FAR	0.076*	0.094**	0.093**	0.094**	0.095**	0.032
	(0.039)	(0.038)	(0.037)	(0.039)	(0.037)	(0.038)
Log-land area	0.064*	0.085**	0.086**	0.083**	0.097***	0.016
	(0.036)	(0.037)	(0.037)	(0.039)	(0.037)	(0.038)
Nearby log-NOI			0.018***			
			(0.006)			
Kleibergen-Paap F	349.42	352.86	403.19	392.13	260.32	307.14
Panel B: 2nd stage – Dependent variable: Redevelopment dummy						
Redevelopment pot.	1.111***	1.182***	1.166***	1.169***	1.127***	1.173***
	(0.059)	(0.063)	(0.058)	(0.059)	(0.070)	(0.067)
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
County FE	Yes	Yes	Yes	Yes	Yes	Yes
Hedonic char.	Yes	Yes	Yes	Yes	Yes	Yes
Market potential	Yes	Yes	Yes	Yes	Yes	Yes
Buyer/seller char.	Yes	Yes	Yes	Yes	Yes	Yes
Observations	72,226	81,928	81,366	81,787	83,610	83,610

Notes: Clustered standard errors at the county level in parentheses $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$. The period of analysis is 2001-2018. A constant term is included in all specifications. Age is measured in decades. NOI is the Net Operating Income per surface unit of the property. FAR is the Floor Area Ratio, corresponding to the total building surface divided by the land surface. See Section 4 for the list of variables included as other hedonic characteristics, market potential, and buyer/seller characteristics. See Section 4.1 for a definition of capital intensity gap and economic activity mismatch.

market signals valuable only via the real option attached to the asset. This assumption is violated if recent nearby development exerts positive externalities on the building's value. Thus, to eliminate the possible positive externalities on the building's value, we first drop all recent developments within 1000 meters of a redevelopment. Column 2 shows the estimated option value is robust to this change. Second, in Column 3, we control for the NOI per square meter generated by recently built properties. This does not significantly alter the redevelopment option value estimate.

Lagged market signals. Recently nearby built properties may have positive externalities on the future revenue-generating ability of existing properties. Controlling for current NOI does not capture this. Thus, as robustness, we lag our market signals. I.e., we construct our instruments with nearby properties built within five to ten years instead of five years. Column 4 shows that running the analysis with the lagged instruments slightly increases the redevelopment option value, but it is not significantly different from our benchmark estimate.

The fact that we find no positive externalities flowing from the new developments to our target properties might seem counter-intuitive at first. However, it should be noted that the distances between our target properties and these new developments is quite large. Also, the rate of new development in the U.S. (or any industrialized country) is quite low. Less than 1% of supply is added on an annual basis, and this is typically on the outskirts of the city. Secondly, there is a burgeoning literature showing how segmented the real estate market is (see, Geltner and Van de Minne, 2017; Cvijanović et al., 2021). Real estate is not only segmented by location and property type (Geltner et al., 2014), but also by age. As a result, older properties do not compete on the same market as new developments for both tenants and investors.

Impact of imputation. As mentioned in Section 4, we impute missing NOI values using those of the closest properties in a given period. We check the robustness of our main results to this imputation in two ways. In the first approach (Column 5), we control for the (log of the) average distance of the nearby buildings used to impute the NOI in a given period. The reasoning is that we want to control for a measure capturing the reliability of the imputation technique. In the second approach (Column 6), we do *not* control for the imputed NOI in our main specifications and check whether this omission is important, given all other controls we use. The estimated option values remain stable for both approaches.

6. Conclusion

We quantify the extent to which two tangible market signals arising from investment decisions of commercial real estate investors – namely, the capital intensity gap and economic activity mismatch between existing and recently built nearby properties – represent a valuable information externality to other investors.

By exploiting a unique data set on commercial real estate transactions containing the institutional investor's stated intent to purchase a property for redevelopment, we find that the two market signals affect the probability of buy-to-redevelop investment strategies at least as much as capital depreciation, a primary driver of real option exercise identified in the existing literature. Geographically close investments signaling a capital intensity gap and type of economic activity mismatch with existing investments spur the immediate exercises of redevelopment options. In contrast, more distant signals act as a deterrent. Our novel identification strategy suggests that when geographically close market signals indicate an economic obsolescence of the existing stock, investors are willing to pay up to 30% more to acquire a property for redevelopment.

Our results hold important lessons for the development of cities and urban renewal. As investors adapt their investment decisions to localized tangible market signals, policymakers aiming to spur real estate investments and re-orient economic activity might implement targeted policies that modify local land-use restrictions to trigger redevelopment cascades, especially in high-demand areas. This appears to be critical from a sustainability perspective, as adapting the existing stock to current economic needs is a better alternative to greenfield development.

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Appendix A. Mathematical derivations

Appendix A.1. Present value formulas

The value P_{it}^N at time t of a property built at time $t_0 < t$ that is *never* redeveloped is

$$\begin{aligned} P_{it}^N &= \int_t^{+\infty} y_{is} c_{is} e^{-r(s-t)} ds = \\ &= \int_t^{+\infty} y_{it} e^{g(s-t)} c_{it_0} e^{-(1-\alpha)\rho(s-t_0)} e^{-r(s-t)} ds = \\ &= y_{it} c_{it_0} e^{-(1-\alpha)\rho(t-t_0)} \int_t^{+\infty} e^{-(r+(1-\alpha)\rho-g)(s-t)} ds = \\ &= \frac{y_{it} c_{it_0}}{r+(1-\alpha)\rho-g} e^{-(1-\alpha)\rho(t-t_0)}, \end{aligned} \tag{A.1}$$

where we have used the fact that $c_{is} = AL_i^\alpha C_{is}^{1-\alpha} = AL_i^\alpha (C_{it_0} e^{-\rho(s-t_0)})^{1-\alpha} = c_{it_0} e^{-\rho(1-\alpha)(s-t_0)}$.

The value P_{it}^R of a building that is redeveloped once is

$$\begin{aligned} P_{it}^R &= \max_{T, C_{iT}} \left(\int_t^T y_{is} c_{it} e^{-r(s-t)} ds + \int_T^{+\infty} y_{is}^R c_{is}^R e^{-r(s-t)} ds - K(C_{it_0}, C_{iT}^R) e^{-r(T-t)} \right) \\ &= \int_t^{+\infty} y_{is} c_{it} e^{-r(s-t)} ds \\ &+ \max_{T, C_{is}^R} \left(+ \int_T^{+\infty} (y_{is}^R c_{is}^R - y_{is} c_{it}) e^{-r(s-t)} ds - K(C_{it_0}, C_{iT}^R) e^{-r(T-t)} \right) = \\ &= P_{it}^N + \max_{T, C_{iT}^R} \left(+ \int_T^{+\infty} (y_{is}^R c_{is}^R - y_{is} c_{it}) e^{-r(s-t)} ds - K(C_{it_0}, C_{iT}^R) e^{-r(T-t)} \right). \end{aligned} \tag{A.2}$$

Because investors maximize the building value, we have

$$\begin{aligned} P_{it} &= \max(P_{it}^N, P_{it}^R) = \\ &= P_{it}^N + \max\left(0, \max_{T, C_{iT}^R} \left(\int_T^{+\infty} (y_{is}^R c_{is}^R - y_{is} c_{it}) e^{-r(s-t)} ds - K(C_{it_0}, C_{iT}) e^{-r(T-t)} \right)\right) = \\ &= P_{it}^N + \max(0, V_{it}^R). \end{aligned} \tag{A.3}$$

Setting the optimal stopping time $T = t$, we have

$$\begin{aligned}
V_{it}^{R} &= \max_{C_{iT}^{R}} \int_{t}^{+\infty} (y_{is}^{R} c_{is}^{R} - y_{is} c_{it}) e^{-r(s-t)} ds - K(C_{it_0}, C_{it}^{R}) = \\
&= \max_{C_{iT}^{R}} \int_{t}^{+\infty} \left(y_{is}^{R} A L_i^{\alpha} C_{it}^{R,1-\alpha} e^{-\rho(1-\alpha)(s-t)} - y_{is} A L_i^{\alpha} C_{it_0}^{1-\alpha} e^{-\rho(1-\alpha)(s-t_0)} \right) e^{-r(s-t)} ds \\
&- k_0 C_{it_0} - k_1 C_{it}^{R} = \\
&= \max_{S_{iT}^{R}} L_i \int_{t}^{+\infty} \left(y_{is}^{R} A S_{it}^{R,1-\alpha} e^{-\rho(1-\alpha)(s-t)} - y_{is} A S_{it_0}^{1-\alpha} e^{-\rho(1-\alpha)(s-t_0)} \right) e^{-r(s-t)} ds \\
&- L(-k_0 S_{it_0} - k_1 S_{it}^{R}).
\end{aligned} \tag{A.4}$$

Let S_{it}^{*R} denote the optimal redevelopment intensity and y_{it}^{*R} the corresponding unitary net operating income. Using (A.4), we have

$$\begin{aligned}
V_{it}^{R} &= L_i y_{it}^{*R} A S_{it}^{*R,1-\alpha} \int_{t}^{+\infty} e^{-(r+\rho(1-\alpha)-g)(s-t)} ds + \\
&L_i y_{is} A S_{it_0}^{1-\alpha} e^{-(1-\alpha)\rho(t-t_0)} \int_{t}^{+\infty} e^{-(r+\rho(1-\alpha)-g)(s-t)} ds - L_i(k_0 S_{it_0} - k_1 S_{it}^{*R}) = \\
&\frac{L_i}{r+\rho(1-\alpha)-g} (y_{it}^{*R} A S_{it}^{*R,1-\alpha} - y_{is} A S_{it_0}^{1-\alpha} e^{-(1-\alpha)\rho(t-t_0)}) - L_i(k_0 S_{it_0} - k_1 S_{it}^{*R}).
\end{aligned} \tag{A.5}$$

We now bring the previous theoretical framework to the our data. The value of a property for which there is an intrinsic redevelopment value is $P_{it} = P_{it}^{N} + V_{it}^{R}$, where V_{it} is given by (A.5). Using (A.1), we have

$$\begin{aligned}
\frac{P_{it}}{L_i} &= \frac{1}{r+\rho(1-\alpha)-g} y_{is} A S_{it_0}^{1-\alpha} e^{-(1-\alpha)\rho(t-t_0)} + \\
&\max \left(\frac{1}{r+\rho(1-\alpha)-g} (y_{it}^{*R} A S_{it}^{*R,1-\alpha} - y_{is} A S_{it_0}^{1-\alpha} e^{-(1-\alpha)\rho(t-t_0)}) - k_0 S_{it_0} - k_1 S_{it}^{*R}, 0 \right) = \\
&= \frac{1}{r+\rho(1-\alpha)-g} y_{is} A S_{it_0}^{1-\alpha} e^{-(1-\alpha)\rho(t-t_0)}. \\
&\left(1 + \max \left(\frac{y_{it}^{*R} S_{it}^{*R,1-\alpha} e^{(1-\alpha)\rho(t-t_0)}}{y_{is} S_{it_0}^{1-\alpha}} - 1 - \frac{K e^{(1-\alpha)\rho(t-t_0)}}{y_{is} A S_{it_0}^{1-\alpha}}, 0 \right) \right) = \\
&= P_{it}^{N} \max \left(\frac{y_{it}^{*R} S_{it}^{*R,1-\alpha} e^{(1-\alpha)\rho(t-t_0)}}{y_{is} S_{it_0}^{1-\alpha}} - \frac{K e^{(1-\alpha)\rho(t-t_0)}}{y_{is} A S_{it_0}^{1-\alpha}}, 1 \right).
\end{aligned} \tag{A.6}$$

Appendix A.2. Optimal stopping time and development

Let us first rewrite V_{it}^R defined in (A.3) as

$$
\begin{aligned}
V_{it}^R &= \max_{T, C_{iT}^R} \int_T^{+\infty} (y_{is}^R c_{is}^R - y_{is} c_{it}) e^{-r(s-t)} ds - K(C_{it_0}, C_{it}^R) e^{-r(T-t)} = \\
&= L_i \max_{T, S_{iT}^R} \int_T^{+\infty} \left(y_{is}^R A S_{it}^{R,1-\alpha} e^{-\rho(1-\alpha)(s-t)} - y_{is} A S_{it_0}^{1-\alpha} e^{-\rho(1-\alpha)(s-t_0)} \right) e^{-r(s-t)} ds \\
&- (k_0 S_{it_0} + k_1 S_{it}^R) e^{-r(T-t)}.
\end{aligned}
\tag{A.7}
$$

Let us re-write the expression to maximize as

$$
\begin{aligned}
&\int_T^{+\infty} y_{iT}^R e^{g(s-T)} A S_{iT}^{R,1-\alpha} e^{-\rho(1-\alpha)(s-T)} e^{-r(s-t)} ds \\
&- \int_T^{+\infty} y_{is} A S_{it_0}^{1-\alpha} e^{-\rho(1-\alpha)(s-t_0)} e^{-r(s-t)} ds \\
&- (k_0 S_{it_0} + k_1 S_{it}^R) e^{-r(T-t)} = \\
&= y_{iT}^R A S_{iT}^{R,1-\alpha} e^{(\rho(1-\alpha)-g)(T-t)} \int_T^{+\infty} e^{-(r+\rho(1-\alpha)-g)(s-t)} ds + \\
&- y_{it_0} A S_{it_0}^{1-\alpha} e^{(g-\rho(1-\alpha))(t-t_0)} \int_T^{+\infty} e^{-(r+\rho(1-\alpha)-g)(s-t)} ds + \\
&- (k_0 S_{it_0} + k_1 S_{it}^R) e^{-r(T-t)} \\
&= y_{iT}^R A S_{iT}^{R,1-\alpha} e^{(\rho(1-\alpha)-g)(T-t)} \frac{e^{-(r+\rho(1-\alpha)-g)(T-t)}}{r+\rho(1-\alpha)-g} + \\
&- y_{it_0} A S_{it_0}^{1-\alpha} e^{(g-\rho(1-\alpha))(t-t_0)} \frac{e^{-(r+\rho(1-\alpha)-g)(T-t)}}{r+\rho(1-\alpha)-g} + \\
&- (k_0 S_{it_0} + k_1 S_{it}^R) e^{-r(T-t)} \\
&= \frac{y_{iT}^R A S_{iT}^{R,1-\alpha}}{r+\rho(1-\alpha)-g} e^{-r(T-t)} + \\
&- \frac{y_{it_0} A S_{it_0}^{1-\alpha}}{r+\rho(1-\alpha)-g} e^{-(\rho(1-\alpha)-g)(T-t_0)} e^{-r(T-t)} + \\
&- (k_0 S_{it_0} + k_1 S_{it}^R) e^{-r(T-t)}.
\end{aligned}
\tag{A.8}
$$

The optimal exercise time is thus characterized by

$$\begin{aligned}\frac{\partial V_{it}^R}{\partial T} = -r\frac{y_{iT}^R A S_{iT}^{R,1-\alpha}}{r+\rho(1-\alpha)-g}e^{-r(T-t)}+ \\ + y_{it_0} A S_{it_0}^{1-\alpha} e^{-r(T-t)} e^{-(\rho(1-\alpha)-g)(T-t_0)}+ \\ + r(k_0 S_{it_0} + k_1 S_{it}^R) e^{-r(T-t)} = 0,\end{aligned} \tag{A.9}$$

which implies

$$\begin{aligned}y_{iT}^R A S_{iT}^{R,1-\alpha} = \frac{r+\rho(1-\alpha)-g}{r} y_{it_0} A S_{it_0}^{1-\alpha} e^{-(\rho(1-\alpha)-g)(T-t_0)} \\ + (r+\rho(1-\alpha)-g)(k_0 S_{it_0} + k_1 S_{it}^R).\end{aligned} \tag{A.10}$$

The optimal structural intensity for a each unit of land is characterized by the following first order condition

$$(1-\alpha)\frac{y_{iT}^R A(1-\alpha) S_{iT}^{R,-\alpha}}{r+\rho(1-\alpha)-g}e^{-r(T-t)} - k_1 e^{-r(T-t)} = 0, \tag{A.11}$$

and an optimal redevelopment capacity $c_{iT}^R = L_i A (S_{iT}^{*R})^{1-\alpha}$. Note that the optimal structural intensity does not depend explicitly on the dynamics of T. The solution of (A.11) characterizes a unique maximum, as

$$-\alpha(1-\alpha)\frac{A y_{it}^R S_{it}^{R,-\alpha-1}}{r+\rho(1-\alpha)-g}e^{-r(T-t)} < 0. \tag{A.12}$$

Appendix B. Data

Appendix B.1. Detailed data description

This Section describes the other control variables. Table B.6 describes the variables included as other hedonic characteristics, market potential, and buyer/seller characteristics, respectively. Table B.7 summarizes these control variables.

Table B.6: **Variables description**

	Hedonic characteristics
Quality score	Index indicating the quality of the property.
Number of units	Number of units in the property.
	Market potential
Walking score	Index indicating the property's foot traffic.
NOI trend	Index indicating the MSA's NOI trend.
Street retail	Dummy indicating if the property is located £ on a street with retail.
Subsidized	Dummy indicating if the property is £ subsidized
Opportunity zone	Dummy indicating if the property is located £ on a opportunity zone.
	Buyer/seller characteristics
Buyer type	Categorical variable indicating the type of buyer. 25 different types, e.g., Developer or Equity fund.
Seller type	Categorical variable indicating the type of seller. 25 different types, e.g., Developer or Equity fund.
Geoscope buyer	Categorical variable indicating the geographic scope of the buyer: Continental, Global, Local, or National.
Geoscope seller	Categorical variable indicating the geographic scope of the seller: Continental, Global, Local, or National.
Deal type	Categorical variable indicating the type of deal. 9 different types.
Distressed	Dummy indicating if the property was distressed when transacted.
Foreign	Dummy indicating if the property was bought by a foreign buyer.

Appendix B.2. Imputation details

Table B.7: **Descriptives: Other control variables**

	Mean	SD	10%	90%
Quality score	0.499	0.292	0.1	0.91
Number of units	8.168	3.427	3.178	11.902
Walking score	59.896	26.733	23	96
Street retail	0.052	0.221	0	0
Subsidized	0.015	0.121	0	0
Opportunity zone	0.126	0.332	0	1
Distressed	0.050	0.219	0	0
Foreign	0.092	0.289	0	0

Notes: SD is the standard deviation, 10% is the 10^{th} quantile and 90% is the 90^{th} quantile. See Table B.6 for the variable description.

Appendix C. The value of market signals for individual buildings

This section provides details about the strategy that we implement to quantify for each building the redevelopment option value arising from the two market signals considered in the main analysis, namely the capital intensity gap and economic mismatch.

As outlined in Section 3.2, we use the following 3SLS estimation procedure to efficiently estimate an unbiased coefficient of the parameter β. First, we predict the probability $\hat{D}_{it}^{Red}$ of purchasing a real estate asset for redevelopment using the probit model (8). Second, we use the fitted probabilities $\hat{D}_{it}^{Red}$ to instrument D_{it}^{Red} in (6) with a 2SLS approach. According to this three-step procedure, we have that

$$\ln P_{it} = c' + \ln(y_{is}) + (1-\alpha)\ln(S_{it_0}) - (1-\alpha)\rho(t-t_0) + \ln L_i + \beta\hat{\hat{D}}_{it}^{Red} + \epsilon'_{it}, \qquad \text{(C.1)}$$

is the third stage equation of the 3SLS estimation, where $\hat{\hat{D}}_{it}^{Red}$ are the fitted predictions obtained by regressing D_{it}^{Red} on $\hat{D}_{it}^{Red}$ in the second stage.

According to (C.1), an unbiased price prediction $\hat{P}_{it}$ of P_{it} is given by

$$\hat{P}_{it} = \exp\left(E(\ln P_{it}|, X_{it}) + \frac{1}{2}\hat{\sigma}^2\right)\exp(\hat{\beta}\hat{\hat{D}}_{it}^{Red}) = \hat{P}_{it}^{N} exp(\hat{\beta}\hat{\hat{D}}_{it}^{Red}), \qquad \text{(C.2)}$$

where X_{it} it the vector of model-based controls contained in (C.1) and $\hat{P}_{it}^{N}$ is the predicted property value when the property is never redeveloped. The term $\frac{1}{2}\hat{\sigma}^2$ is a standard adjustment component used to obtain unbiased predictions of $\hat{P}_{it}^{N}$ when the error term follows a normal distribution with standard deviation σ.[34]

The term $\hat{\hat{D}}_{it}^{Red}$ on the right-hand side of (C.2) correspond to the redevelopment option value shifter. We can re-write (C.2) as $\hat{P}_{it} = \hat{P}_{it}^{N}(1 + s_{it})$, where $s_{it} = \exp(\hat{\beta}\hat{\hat{D}}_{it}^{Red}) - 1$. The term $\hat{P}_{it}^{N} s_{it}$ thus represents the part of the property value that arises from the redevelopment option. To compute this term we therefore proceed as follows:

1. We predict the probability $\hat{D}_{it}^{Red}$ using the probit model (8).
2. We predict the fitted probabilities $\hat{\hat{D}}_{it}^{Red}$ by regressing $\hat{D}_{it}^{Red}$ on D_{it}^{Red} (always using the full set of controls).
3. We estimate (C.1) and
    i) We estimate $E(\ln P_{it}|X_{it})$. and compute $\hat{P}_{it}^{N}$ by adding the adjustment term $\frac{1}{2}\hat{\sigma}^2$ and taking the exponential.
    ii) use the estimated $\hat{\beta}$ to compute $s_{it} = \exp(\hat{\beta}\hat{\hat{D}}_{it}^{Red}) - 1$.
4. We compute the option value $\hat{P}_{it}^{N} s_{it}$.

---

[34] The estimator $\hat{\sigma}$ of the standard deviation σ is given by the root mean squared error of the estimated residuals in (C.1). The adjustment term $\frac{1}{2}\hat{\sigma}^2$ is necessary because taking the exponential of the predicted log prices in (C.1) does not provide unbiased price values due to the non linearity of the exponential function.

Appendix D. Further robustness checks

We perform further robustness checks to verify the sensitivity of our redevelopment option value estimates. For space reasons, we only report robustness checks for our most conservative estimate reported in Column 4 (full set of controls) of Table 4. Table D.8 summarizes these results.

Non-linear depreciation scheme In our main log-linear specifications, we control for building age linearly. However, a common approach in the hedonic literature is to control for age polynomials to capture a wider spectrum of nonlinearities in the depreciation of invested capital.[35] To test the impact of the linear depreciation assumption on our option value estimates, in equation (6), we generalize the parametrization of the depreciation rate to a second-degree polynomial in the building age, i.e., $\rho = \rho_1 + \rho_2(t - t') + \rho_3(t - t')^2$. Column 1 shows that the estimated option value, although of a slightly lower magnitude, remains essentially the same.

Market segmentation In Section 3, we argue against using the (log of the) NOI gap $y^{*R}_{it}/y_{it'}$ between HBU properties and previously built ones to instrument D^{Red}_{it}, thereby excluding such a variable from our regressions. We argue that *conditional on the other model controls*, such a variable captures the extent to which the market of HBU and existing commercial properties is segmented. If there is no segmentation, the equilibrium NOI per capacity unit should be the same across all properties, implying $y^{*R}_{it}/y_{it'} = 1$. An open question is whether this measure of market segmentation – which might be contained in the error term of equation (6) – correlates with the two instruments we use to derive our main results, thus biasing our option value estimates. Column 2 shows that this is not the case.

Classic 2SLS estimates We investigate how 3SLS estimates compare to classic 2SLS estimates, where the two instruments z^{Gap} and z^{Mism} are directly regressed on D^{Red} in the first stage. Additionally, we investigate endogeneity issues by performing an overidentification test when the two instruments are used simultaneously in the 2SLS estimation procedure. Column 3 shows that the estimated coefficient is extremely close to our baseline estimate but

---

[35] See, for example, Clapp and Salavei (2010) and Clapp et al. (2012).

Table D.8: **Robustness: Intrinsic redevelopment option value**

Panel A: Dependent variable: Log-price – 3rd stage (Columns 1-3) – OLS (Column 4)				
	(1)	(2)	(3)	(4)
Redevelopment (D^{Red})	0.253**	0.295***	0.317	
	(0.118)	(0.112)	(0.418)	
Age	-0.029**	-0.006***	-0.007	-0.004*
	(0.014)	(0.002)	(0.005)	(0.002)
Log-NOI	0.127***	0.138***	0.133***	0.133***
	(0.007)	(0.007)	(0.007)	(0.007)
Log-FAR	0.093***	0.092**	0.093**	0.110***
	(0.036)	(0.037)	(0.038)	(0.036)
Log-land area	0.090***	0.086**	0.086**	0.098***
	(0.035)	(0.036)	(0.039)	(0.036)
Capital intensity gap				0.015**
				(0.007)
Economic activity mism.				-0.027
				(0.028)
Kleibergen-Paap F	364.85	370.98	17.39	
Panel B: 2nd stage – Dependent variable: Redevelopment dummy				
Redevelopment pot.	1.174***	1.167***		
	(0.061)	(0.061)		
Capital intensity gap			0.019***	
			(0.003)	
Economic activity mism.			0.025***	
			(0.008)	
Year FE	Yes	Yes	Yes	Yes
County FE	Yes	Yes	Yes	Yes
Hedonic char.	Yes	Yes	Yes	Yes
Market potential	Yes	Yes	Yes	Yes
Buyer/seller char.	Yes	Yes	Yes	Yes
Observations	83,610	81,366	83,610	83,610

Notes: Clustered standard errors at the county level in parentheses $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$. The period of analysis is 2001-2018. A constant term is included in all specifications. Age is measured in decades. NOI is the Net Operating Income per surface unit of the property. FAR is the Floor Area Ratio, corresponding to the total building surface divided by the land surface. See Section 4 for the list of variables included as other hedonic characteristics, market potential, and buyer/seller characteristics. See Section 4.1 for a definition of capital intensity gap and economic activity mismatch.

considerably less precise. Indeed, the Kleibergen-Paap F statistic is considerably lower than those obtained using a 3SLS approach. The Stock-Yogo critical values suggest that the two instruments might be weak, thereby supporting the usage of the 3SLS estimation procedure. As pointed out by Wooldridge (2010), the 3SLS procedure improves the predictive power and efficiency of the instruments. Finally, we note that the overidentification test does not

Table D.9: **Robustness: Intrinsic redevelopment option value with county interactions**

Panel A: 3rd stage – Dependent variable: Log-price						
	(1)	(2)	(3)	(4)	(5)	(6)
Redevelopment (D^{Red})	0.217**	0.240*	0.222**	0.255**	0.130	0.195**
	(0.103)	(0.124)	(0.105)	(0.118)	(0.089)	(0.093)
Age	-0.005***	-0.006**	-0.007***	0.010	-0.003*	-0.005**
	(0.002)	(0.002)	(0.002)	(0.007)	(0.002)	(0.002)
Log-NOI	0.131***	0.130***	0.126***	0.116***	0.186***	0.119***
	(0.007)	(0.007)	(0.006)	(0.006)	(0.015)	(0.006)
Log-FAR	0.093**	0.091**	0.086**	0.090**	0.079**	0.111***
	(0.038)	(0.039)	(0.038)	(0.036)	(0.038)	(0.036)
Log-land area	0.086**	0.085**	0.067*	0.085**	0.076**	0.082**
	(0.038)	(0.039)	(0.036)	(0.036)	(0.038)	(0.037)
Kleibergen-Paap F	1669.94	1225.38	217.67	303.45	471.02	303.55
Panel B: 2nd stage – Dependent variable: Redevelopment dummy						
Redevelopment pot.	1.096***	1.067***	1.164***	1.096***	1.121***	1.111***
	(0.027)	(0.030)	(0.079)	(0.063)	(0.052)	(0.064)
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
County FE	Yes	Yes	Yes	Yes	Yes	Yes
Hedonic char.	Yes	Yes	Yes	Yes	Yes	Yes
Market potential	Yes	Yes	Yes	Yes	Yes	Yes
Buyer/seller char.	Yes	Yes	Yes	Yes	Yes	Yes
Observations	77,724	78,458	78,334	76,099	78,445	78,996

Notes: Clustered standard errors at the county level in parentheses $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$. The period of analysis is 2001-2018. A constant term is included in all specifications. Age is measured in decades. NOI is the Net Operating Income per surface unit of the property. FAR is the Floor Area Ratio, corresponding to the total building surface divided by the land surface. See Section 4 for the list of variables included as other hedonic characteristics, market potential, and buyer/seller characteristics. See Section 4.1 for a definition of capital intensity gap and economic activity mismatch. Columns (1), (2), (3), (4), (5), and (6) include the capital intensity gap, economic activity mismatch, log-land area, age, log-NOI, and log-FAR interacted with county fixed effects, respectively.

highlight significant endogeneity issues when the two instruments are used simultaneously, adding further evidence supporting the exogeneity of the instruments.

OLS log-price on instruments To underlay the downward bias when running an OLS, we regress log-prices directly on our instruments, including the full set of controls. Column 4 shows that our primary instrument, the capital intensity gap, positively and significantly affects the transaction price.

Table D.10: **Determinants of the investors' intent to redevelop with capital intensity gap interactions**

Dependent variable: Redevelopment dummy (D^{Red}) - 1st stage estimates				
	(1)	(2)	(3)	(4)
Market signals				
Capital intensity gap	0.187***	0.205***	0.213***	0.213***
	(0.026)	(0.029)	(0.026)	(0.027)
Economic activity mism.	0.236***	0.214***	0.212***	0.221***
	(0.075)	(0.073)	(0.072)	(0.073)
Interactions				
Capital intensity gap × residential	0.076			
	(0.052)			
Capital intensity gap × industrial		0.000		
		(0.042)		
Capital intensity gap × office			-0.028	
			(0.027)	
Capital intensity gap × retail				-0.026
				(0.032)
Year FE	Yes	Yes	Yes	Yes
County FE	Yes	Yes	Yes	Yes
Hedonic char.	Yes	Yes	Yes	Yes
Market potential	Yes	Yes	Yes	Yes
Buyer/seller char.	Yes	Yes	Yes	Yes
Observations	83,610	83,610	83,610	83,610
AIC	22,090	22,096	22,095	22,095

Notes: Clustered standard errors at the county level in parentheses $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$. Estimation is carried out using a probit model. The period of analysis is 2001-2018. A constant term is included in all specifications. See Section 4 for the list of variables included as other hedonic characteristics, market potential, and buyer/seller characteristics. See Section 4.1 for a definition of capital intensity gap and economic activity mismatch.

Appendix E. Tables

Table E.14 shows the classic first (Panel B) and second stage (Panel A) 2SLS estimates using the capital intensity gap (Column 1), the economic activity mismatch (Column 2), and both together (Column 3) as instruments.

Table D.11: **Intrinsic redevelopment option value with capital intensity gap interactions**

Panel A: 3rd stage – Dependent variable: Log-price				
	(1)	(2)	(3)	(4)
Redevelopment (D^{Red})	0.319***	0.401***	0.268	0.274**
	(0.108)	(0.116)	(0.179)	(0.120)
D^{Red} × residential	0.541			
	(0.490)			
D^{Red} × industrial		-0.342**		
		(0.173)		
D^{Red} × office			0.079	
			(0.247)	
D^{Red} × retail				0.118
				(0.177)
Kleibergen-Paap F	33.86	113.94	153.30	151.87
Panel B: 2nd stage – Dependent variable: Redevelopment dummy				
Redevelopment pot.	1.144***	1.136***	1.218***	1.138***
	(0.062)	(0.076)	(0.070)	(0.064)
Redevelopment pot. × residential	-0.486***			
	(0.063)			
Redevelopment pot. × residential		0.140**		
		(0.071)		
Redevelopment pot. × residential			-0.082	
			(0.054)	
Redevelopment pot. × residential				0.124***
				(0.045)
Year FE	Yes	Yes	Yes	Yes
County FE	Yes	Yes	Yes	Yes
Hedonic char.	Yes	Yes	Yes	Yes
Market potential	Yes	Yes	Yes	Yes
Buyer/seller char.	Yes	Yes	Yes	Yes
Observations	83,610	83,610	83,610	83,610

Notes: Clustered standard errors at the county level in parentheses $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$. The period of analysis is 2001-2018. A constant term is included in all specifications. See Section 4 for the list of variables included as other hedonic characteristics, market potential, and buyer/seller characteristics. See Section 4.1 for a definition of capital intensity gap and economic activity mismatch.

Table D.12: **Determinants of the investors' intent to redevelop with economic activity mism. interactions**

Dependent variable: Redevelopment dummy (D^{Red}) - 1st stage estimates				
	(1)	(2)	(3)	(4)
Market signals				
Capital intensity gap	0.213***	0.204***	0.204***	0.211***
	(0.025)	(0.025)	(0.025)	(0.026)
Economic activity mism.	0.149**	0.204**	0.231***	0.266***
	(0.074)	(0.081)	(0.083)	(0.096)
Interactions				
Economic activity mism. × residential	0.221			
	(0.222)			
Economic activity mism. × industrial		0.051		
		(0.186)		
Economic activity mism. × office			-0.069	
			(0.109)	
Economic activity mism. × retail				-0.195
				(0.142)
Year FE	Yes	Yes	Yes	Yes
County FE	Yes	Yes	Yes	Yes
Hedonic char.	Yes	Yes	Yes	Yes
Market potential	Yes	Yes	Yes	Yes
Buyer/seller char.	Yes	Yes	Yes	Yes
Observations	83,610	83,610	83,610	83,610
AIC	22,090	22,096	22,096	22,092

Notes: Clustered standard errors at the county level in parentheses $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$. Estimation is carried out using a probit model. The period of analysis is 2001-2018. A constant term is included in all specifications. See Section 4 for the list of variables included as other hedonic characteristics, market potential, and buyer/seller characteristics. See Section 4.1 for a definition of capital intensity gap and economic activity mismatch.

Table D.13: **Intrinsic redevelopment option value with economic activity mism. interactions**

	(1)	(2)	(3)	(4)
Panel A: 3rd stage – Dependent variable: Log-price				
Redevelopment (D^{Red})	0.383***	0.401***	0.268	0.284**
	(0.110)	(0.116)	(0.180)	(0.122)
D^{Red} × residential	0.827*			
	(0.500)			
D^{Red} × industrial		-0.345**		
		(0.174)		
D^{Red} × office			0.088	
			(0.250)	
D^{Red} × retail				0.140
				(0.177)
Kleibergen-Paap F	34.43	114.61	149.11	152.06
Panel B: 2nd stage – Dependent variable: Redevelopment dummy				
Redevelopment pot.	1.130***	1.138***	1.223***	1.133***
	(0.063)	(0.076)	(0.071)	(0.064)
Redevelopment pot. × residential	-0.477***			
	(0.065)			
Redevelopment pot. × residential		0.131*		
		(0.071)		
Redevelopment pot. × residential			-0.093*	
			(0.054)	
Redevelopment pot. × residential				0.128***
				(0.044)
Year FE	Yes	Yes	Yes	Yes
County FE	Yes	Yes	Yes	Yes
Hedonic char.	Yes	Yes	Yes	Yes
Market potential	Yes	Yes	Yes	Yes
Buyer/seller char.	Yes	Yes	Yes	Yes
Observations	83,610	83,610	83,610	83,610

Notes: Clustered standard errors at the county level in parentheses $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$. The period of analysis is 2001-2018. A constant term is included in all specifications. See Section 4 for the list of variables included as other hedonic characteristics, market potential, and buyer/seller characteristics. See Section 4.1 for a definition of capital intensity gap and economic activity mismatch.

Table E.14: **IV**

	(1)	(2)	(3)
Panel A: 2nd stage – Dependent variable: Log-price			
		IV	
Redevelopment	0.845*	-1.359	0.317
	(0.459)	(1.668)	(0.418)
Kleibergen-Paap F	32.94	7.62	17.39
Overidentification	.	.	0.14
Panel B: 1st stage – Dependent variable: Redevelopment dummy			
Capital intensity gap	0.018***		0.019***
	(0.003)		(0.003)
Economic activity mism.		0.022***	0.025***
		(0.008)	(0.008)
Year FE	Yes	Yes	Yes
Hedonic char.	Yes	Yes	Yes
Market potential	Yes	Yes	Yes
Buyer/seller char.	Yes	Yes	Yes
Observations	83,610	83,610	83,610

Robust standard errors in parentheses ${}^{*}p < 0.10$, ${}^{**}p < 0.05$, ${}^{***}p < 0.01$. For the IV models, we instrument for the redevelopment dummy with the fitted redevelopment potential. In the first IV (i) model, we only use the fitted redevelopment potential estimated with the NOI instrument. In the second IV (ii) model, we use the fitted redevelopment potential estimated with the FAR instrument and HBU property type index. In the third IV (iii) model, we use the the three instruments together. The period of analysis is 2001-2018. A constant term is included in all specifications. See Section 4 for the list of variables included as other hedonic characteristics, market potential, and buyer/seller characteristics. See Section 4.1 for a definition of capital intensity gap and economic activity mismatch.