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Urban Density and Land Leverage: Market Value Breakdown for Energy-Efficient Assets

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Abstract: A real estate asset comprises land and improvements. The proportions of these components vary over time and across locations. Notably, the land value component is consistent over time, unaffected by depreciation. Consequently, the weight of land value in determining the overall asset value is crucial, particularly in those improvements that are highly sensitive to depreciation, such as energy-efficient buildings. While several studies have explored the relationship between energy-efficient building consumption and urban density, there is currently a research gap concerning the relationship between land value and the value of efficient improvements built on it. Before investigating this potential relationship, it is imperative to preliminary examine any possible correlations between land values and land density. To verify this correlation, we captured the "Land Leverage" of a real estate property by calculating the ratio between the value of the land and the total value of the real estate property and correlating it with the allowable density. Our analysis of the Land Leverage (LL) trend in a restricted development area over a ten-year period demonstrates that LL increases with the level of permitted density in a neighborhood. This evidence will serve as the foundation to verify whether Land leverage, through urban-densification strategies, might be a pivotal factor in driving the values of energy-efficient assets.

Keywords: real estate values; urban density; land leverage; sustainable indicators; energy-efficient building; depreciated replacement cost

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1. Introduction

Houses, better identified as real properties (RP), are recognized to be bundled goods. Both academic literature and Uniform Standards have recognized RP as a bundle of land, improvements, and associated rights [1–4]. By definition, real estate (RE) encompasses the physical land along with all natural and manmade elements attached or appurtenant to it. RP's definition includes the concept of RE, incorporating ownership rights over the RE, also referred to as a bundle of rights [5]; see Figure 1. This distinction is relevant as our study aims to quantify the value of the land as a percentage of the total value, taking it for granted that these two values are separable and independently assessable [6]. The land value ratio, i.e., the ratio of the land's value to the total real property value, is also called Land Leverage in the literature (LL).

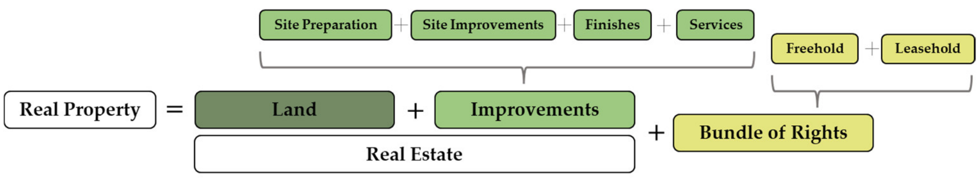

Figure 1. Real property's components. Source: authors.

Given that the value of the land is not sensitive to depreciation due to functional, economic, or physical obsolescence, it is relevant to define its leverage as a pivotal factor to investigate not only real estate market trends but also the trends of the values of the features and the performances of the improvements that are built on it, commonly defined as buildings.

In developed regions, urban areas stand as significant contributors to climate change and greenhouse gas (GHG) emissions, consuming approximately 60% to 80% of global energy consumption, accounting for an equal share of global carbon dioxide emissions [7]. Meanwhile, buildings play a pivotal role in energy consumption, reaching a higher percentage (38.1%) of total energy consumption within the European Union, surpassing other sectors such as transportation (33.3%) and industry (25.9%) [8]. In particular, the residential sector, which is the larger stock in RE, holds the primary responsibility for energy consumption within buildings [9]. Considering this, one of the most interesting features to be investigated in the building sector is the energy efficiency performance of an asset and its change in value. To explore the relationship between the value of energy-efficient buildings and the value of the land, we are currently engaged in a larger-scale project that comprises three distinct phases (Figure 2). In Phase I, which has already been concluded, we verified correlations between land prices and densification policies, suggesting that density is a value-added feature that affects land prices, with higher values in denser areas [10,11]. Following Phase I's findings, which highlighted that density changes the percentage composition of economic factors such as the incidence of costs and land value [10], we are currently developing Phase II to investigate possible correlations between density and Land Leverage. The insights from Phase II will serve as the groundwork for our future research (Phase III), aiming to investigate the potential impact of urban densification strategies on leveraging land as a key factor in enhancing the value of energy-efficient real estate assets.

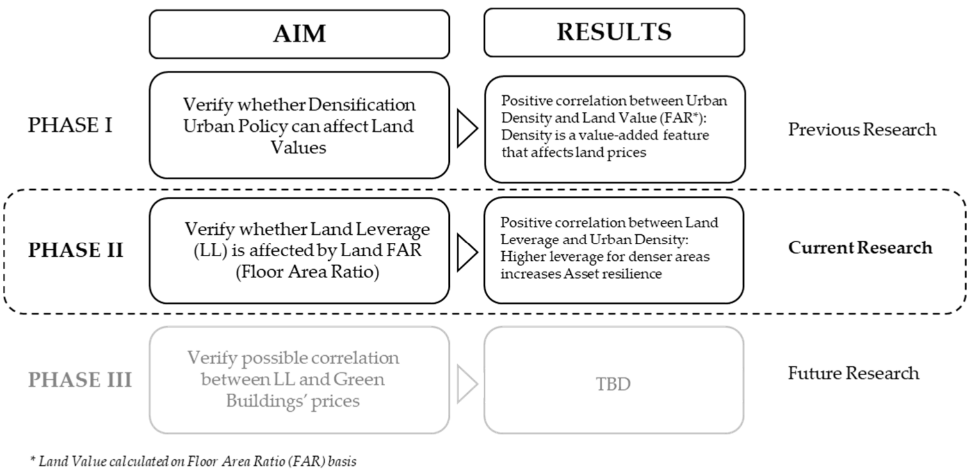

Figure 2. Details of the research project phases. Source: authors.

Given the scope of this larger research project, this study wants to investigate possible relationships between land value, accounted as Land Leverage, and urban density. To achieve this, we collected a time series of sales that occurred in Boston between 2012 and 2022. The database comprises land transactions within a delimited region near the Seaport area. This area was involved in 2016 in an urban planning change that increased the permitted Floor Area Ratio (FAR) limit, increasing the area's permitted density. Our analysis seeks to determine whether urban density can affect Land Leverage and, consequently, trends within the RE market. The outcomes of this study will provide insights into the dynamics of densification on RE market prices, broken down into land and improvement values. These results will provide insights in Phase III into how densification policies might influence the values of energy-efficient improvements.

There are five sections in this study. Following the introduction in Section 1, Section 2 details the related literature review, and Section 3, after presenting the case study and data, designs materials and methodology, including the research design and search strategy.

Section 4 deals with the results obtained, and it presents the discussion focusing on the relationship between Land Leverage and density. Section 5 discusses the conclusion, limitations, and future research directions.

2. Literature Review

The literature has extensively investigated the existing relationship between building energy consumption and urban density. Most of these studies centered on the impact of building design, height, and urban density on energy efficiency and consumption. They revealed that denser urban developments result in lower energy consumption within urban areas [12–21]. Considering that density is a factor that primarily influences construction costs and land values, several studies have been run on the correlation between density and costs; however, to date, there are no studies that specifically investigate the potential relationship between the value of the land and value of energy-efficient buildings (EEBs), which are built on it. To fill this gap, this is investigated in Phase III of our study. This paper will also lay the preliminary basis, focusing on Phase II, where we will investigate the possible correlation between Land Leverage and urban density.

In the literature, there is a long tradition that studies land value trends in urban economics. In the early literature, land values accounted for their distance from the urban center to explain spatial price trends [22–24]. As a result of their research, the higher demand for land in close proximity to the urban center affects the overall prices, identifying a gradient of appreciation on these values. This price gradient has been translated into a Land Leverage gradient, i.e., the ratio of land value to total property value, which varies within urban areas [3]. The literature features numerous studies on how Land Leverage varies over time, across location, and over land usage to capture price volatility—for example, due to inflation, construction costs, gross domestic product (GDP), and population growth [2].

The value of an asset hinges on four main characteristics, abbreviated as DUST (Demand, Utility, Scarcity, and Transferability). Considering these four dimensions, the literature has extensively investigated the relationship between the land ratio and market demand and scarcity across time and location. According to Scarcity Theory, land values will continue to rise because of scarcity, and this trend will persist in the foreseeable future. The increase in land value is the foremost driver of purchase price growth. Moreover, the resilience of Land Leverage against depreciation can significantly impact a landowner's eligibility to secure financing.

In addition, the LL ratio is used by banks and lenders to assess the worth of a property and the amount of financing they are ready to offer. For these reasons, given the profound impact of LL on RE market values, it is crucial to study the relationship that exists between land value and the values of the improvements. However, considering the "DUST" features, the existing literature only partially investigated how the value of land can be influenced by its utility. Utility can be described by the potential for land to be developed with improvements. This transformability can be investigated through two zoning aspects: the potential use of the developable land (i.e., residential or commercial use) or the allowable volume to be built on the parcel of land. While the former has received considerable attention in the literature [3,25], there is a gap in exploring the latter aspect that warrants further investigation.

As previously mentioned, several studies have concentrated on examining the existing correlation between LL and the RE market trends across time, location, and land use. In the early XI century, the literature started investigating LL in relationship with house price trends throughout the US. Bostic et al. accounted for land values with two different approaches. In the first approach, they compared the prices of vacant lots with their prices after development. In the second approach, they used the assessed values assigned to land and improvements as determined by the local property tax assessor office. Both samples yield comparable findings regarding the impact of Land Leverage on house price inflation within a city [3]. Similarly, Davis and Heathcote [26], analyzing residential land sales from the late 1970s to the early 2000s, found that land prices quadrupled while improvement prices grew by only one third. Over this period, LL increased by 27% in 30 years (from 35% in 1975 to 46% in 2006). They calculated the land price indexes by considering housing market values of the 2000 decennial census for RE prices and construction costs released by the Federal Housing Finance Agency and by the Bureau of Economic Analysis, to be subtracted to obtain land values. Considering the above, they calculated a LL index through time, and further, they regressed these values (real house, land, and structure prices) on a set of independent variables, such as real per capita income, demographic variables, inflation rates, mortgage rates, and Treasury Bill rates. By considering Land Leverage within this framework, they gained valuable insights into the dynamics of house prices. Another relevant study, involving the residual land value method, was developed by Davis and Palumbo [27]. By using residential construction cost data to assess the price of housing stock, they investigated LL for residential single-family developments in several US metropolitan areas between 1984 and 2004. They accounted for an increase in LL of 51% during the considered time frame. Verifying the rise in land prices, recent studies during the last decade focused on LL as a function of the RE market value using spatial autoregressive models to estimate the factor decomposition results of housing prices [2,4,28–31]. Summarizing, to separate the land value from the other components of the property value to calculate the LL, the above-mentioned studies applied two methods. Some studies focused on the unit sale price of vacant, unimproved land parcels, comparing them with RE market prices in the same areas [32–35]. Meanwhile, other studies, similar to the current work's aims, estimated the land value by applying the residual land value method as a residual by subtracting the development cost from the sale price of the developed property [4,26,27,36–40].

In line with the purpose of our current research, which aims to explore the potential correlation between LL and urban density, we analyzed the existing literature available. Copious literature has been produced on the relationship between land prices and urban density as one of the two main factors (land use policy vs. location) able to determine land supply elasticity [28,41]. However, very limited literature has been written on the land-to-building ratio. Sever studies focused on the influence of land use plans or zoning laws on land values [10,11,42–46]. Urban growth boundary constraints, densification policies, and building permits represent common tools within land use plans and zoning regulations. Building permits, alongside zoning and planning restrictions, exert a significant influence on the density of urban development [47]. Constraints placed on the density of developable land diminish achievable profits, reducing developers' willingness to pay and consequently decreasing total land value. Numerous studies have corroborated the intuitive economic theory that the greater the potential development volume, the greater the land value, which varies significantly across cities and locations within cities [48–50]. These empirical studies have demonstrated a direct correlation between land values and the effective FAR of a parcel. Two recent studies demonstrated that density and therefore densification policies are value-added tools able to increase land value on a FAR basis. This indicates that communities and developers valued density with a greater willingness to pay, internalizing the economic, social, and environmental sustainability benefits [10,11], and that the land market is considerably distorted by excessive administrative interventions by local governments [51]. Alongside studies on density and price increases, there are studies that have verified and quantified the rise in sales prices and rents of energy-efficient assets. In Germany, through the application of a hedonic price model, Taruttis and Webe found a positive correlation between EEBs and their sale prices, with an average increase of 6.9% when energy efficiency climbs by 100 kWh/m^2 [52]. Moreover, their study unearthed regional differences, attributing lower energy-efficiency premiums to factors like housing scarcity and increased purchasing power per capita. In China, the results, however, lead to a smaller increase in property prices, approximately 0.583% in higher EEBs [53]. In the US, several studies confirmed price premiums for EEBs ranging from 1.2% to 16.5% across the States [54–59]. Furthermore, a recent literature review has been conducted on approximately 50 previous studies worldwide regarding the price premium that consumers are willing to pay for energy-efficient buildings [60]. This study identifies the most commonly used approach as the hedonic price model and reveals that all studies have estimated a positive price premium with a rather diversified range across continents, states, and property types [60–63]. All these studies are important because by identifying a price premium and thus a marginal price related to energy efficiency that society is willing to pay, they lay the groundwork and guide government policies in creating sustainability awareness. The ecological impact of such assets is therefore reflected in both social and financial aspects and performances. By implementing political and social actions, like urban densification, governments and local administrations can enhance not just the socio-ecological quality of urban areas but also improve the financial and economic performance of real estate assets [64–66].

The literature has thus far confirmed two crucial points: (i) the existence of a price premium in highly energy-efficient buildings and (ii) the increase in value in areas with higher density. However, a direct examination of the potential correlation between price premiums of energy-efficient buildings and urban density has not yet been conducted. To fill this gap, which will be addressed in Phase III of our study, we want to first investigate whether and how density can influence land prices in terms of Land Leverage. Land Leverage represents the distribution of values between improvements and vacant land, defining the non-depreciating portion of the asset value. The current phase of our research will focus on a specific area where recent changes in land use regulations have altered urban density. The aim is to empirically assess the effects of densification tools on Land Leverage.

3. Materials and Methods

3.1. Data

The survey was held in a limited neighborhood in the Seaport District of Boston. This area went through a densification zoning process in 2016 that allowed for higher and denser developments, increasing permitted FAR. Prior to 2016, this area, called Dorchester Corridor, spanning 144 acres, was characterized by low population density and was experiencing a depopulation trend. The new urban plan, approved in 2016 by the Local Authorities, increased the local density from the previously approved 2.0 FAR, allowing for additional building heights of up to 300 feet. Considering the setback requirements, building floor plate dimensions, and lot coverage constraints, the potential redevelopment gross area has now been expanded to 4.7 FAR, effectively more than doubling the previous density level.

The overall sample includes 112 land transactions that occurred during the last decade (2012–2022) in this restricted Corridor. The collected data have been sampled from Massachusetts Land Records [67], Registry of Deeds [68], and includes, where available, the address of the asset, recording date of transaction, book and page of the deed, sale price (LV_i), and grantor and grantee. For each transaction, we estimated the potential density of each parcel with two approaches. Where the parcel was already improved, we reported the Gross Floor Area (GFA_i) of the existing improvements. If vacant, and redevelopment plans were presented at the time of the transaction, we used the proposed GFA_i to calculate the potential FAR of the sold parcel. If no development plans were presented, we applied the allowable FAR per the existing urban plan. For each land sale, we therefore calculated the maximum allowable GFA_i for each parcel.

Additionally, we collected construction cost prices (CC_i) sourced from Marshall Valuation Services in manuals, which provide annual building cost data categorized by type, class, and quality of the finishing throughout the US. We adjusted these direct costs, accounting for location, building height, number of stories, and building class. Additionally, we recalibrated these costs (aCC_i) to encompass indirect expenses and developer profit as a percentage of the direct costs.

Finally, to verify any potential correlation between land price trends and the RE market and construction costs trend, we defined two different indexes. We collected

398 transactions of residential multifamily that occurred in the same timeframe period and in the same geographical area to build a Multifamily Transaction Price Index [10]. Ultimately, using the above-mentioned costs published by Marshall Valuation Services, we inferred a Construction Cost Index covering the analyzed timeframe.

3.2. The Method—Measuring Land Leverage

To calculate Land Leverage for each transaction of our survey, we applied the reverse equivalent of the land residual technique. Usually, this method estimates the building value as equal to the cost to replace the existing improvement minus its depreciation, both assessed at the time of sale. The land value is then determined as the difference between the property value and depreciated replacement cost. As said, the residual land value is a commonly employed method for determining the value of land suitable for development. This method involves subtracting all costs associated with the development, including profit, while excluding the land cost from the total value of the project. The model's assumptions rely on the premise that the construction costs to build a brand-new building, eventually accounting for depreciation, are easily determined in the local market. In our case, since we collected land values, we used this method to estimate the production costs of the allowable development to be added to land value to obtain the overall RE value of the developed land. The method involves calculating the construction cost of each potential development to be built in the sold parcel by multiplying the allowable FAR by the adjusted construction cost per square foot, as published by Marshall and Swift. No physical, functional, or economic depreciation was factored into our considerations as we are considering building a brand-new asset.

For each transaction (i), the total value of a RE development, REV_i, can be separated into the value of the land, LV_i, and the value of the improvements, IV_i, as follows:

$$REV_i = LV_i \times IV_i \tag{1}$$

As previously mentioned, LV_i are known data that we collected over the indicated timeframe. Instead, we calculated the IV_i values as follows:

$$IV_i = GFA_i \times aCC_i \tag{2}$$

where aCC_i is the adjusted Construction Cost (USD/SF) of the potential improvement to be built, and the GFA_i is the gross floor area that can be built by law in the sold land parcel, and it is calculated as follows:

$$GF_i = FAR_i \times BL_i \tag{3}$$

where FAR_i is the Floor Area Ratio allowed and BL_i is the buildable land area of the sold parcel in square feet.

As said in the previous section, the Construction Costs (aCC_i) have been derived from the annually updated Construction Costs Manuals published by Marshall Valuation Services. We selected the most appropriate costs (USD/SF) in relation to the allowable development, considering type, class, and quality. We adjusted these direct costs, accounting for location, building height, number of stories, and building class. We also revised these construction costs, including indirect costs (10% of the base Construction Cost CC_i) and developer profit (15% of the CC_i), as direct cost percentages to obtain the production costs of the potential development.

Having calculated the overall REV_i for each transaction, Formula (1), we can finally determine the Land Leverage (LL_i) as follows:

$$LL_i = \frac{LV_i}{REV_i} \tag{4}$$

To verify the possible correlation between density and Land Leverage, we finally divided the overall land transaction sample into two groups (Figure 3). GroupB included the LL_i for each transaction that occurred before plan approval over a period of time between 2012 and 2015. GroupA included the LL_i for each transaction that occurred after plan approval during the timeframe spanning from 2016 to 2022.

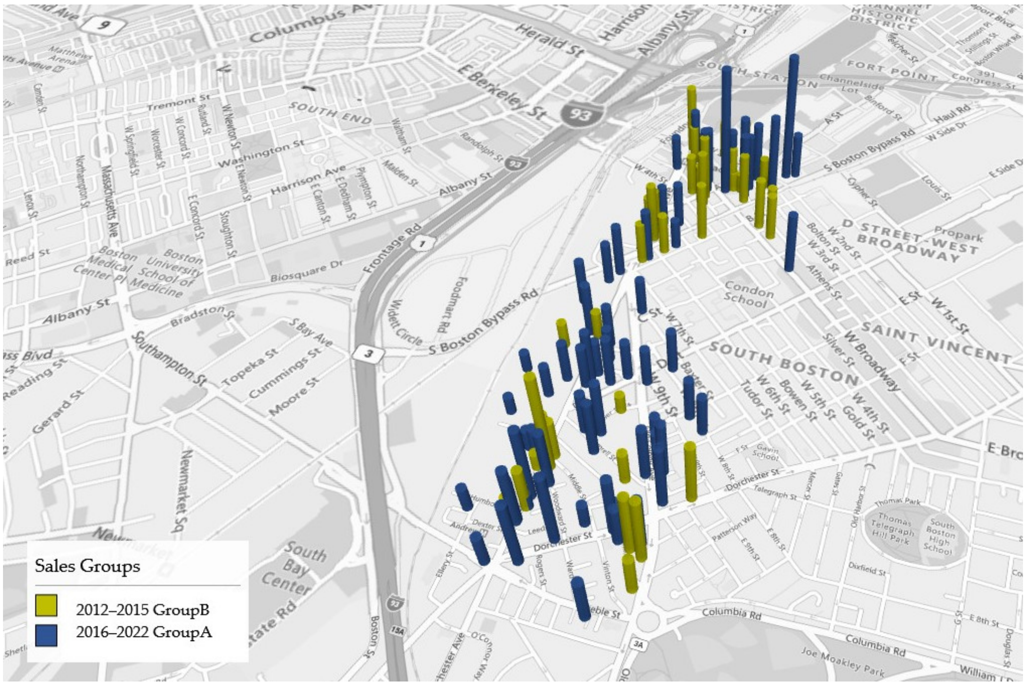

Figure 3. Geo-localization of the land transactions per group (GroupB and GroupA). The height of the graph bars represents the LL_i for each transaction. Source: authors.

Moreover, aiming to verify possible similarities in market trends, we compared the land's historical price trend with residential price and construction cost trends during the survey period. To accomplish this, we calculated an annual index normalizing the average annual transaction prices for land transaction (LI_i), for residential transaction (RI_i), and for construction cost prices (CI_i). The indexes were calculated as follows:

$$I_i = (AAUP_i \times 100)/AAUP_{base} \tag{5}$$

where i indicates the year, I_i is the annual price index calculated for each year, $AAUP_{base}$ is the Annual Average Unit Price (or cost) recorded in the base year 2012, and $AAUP_i$ is the Annual Average Unit Price (or cost) in year i. $AAUP_i$ was reported on an SF of GFA basis for land transactions and on an SF basis for residential transactions and for Construction Costs.

After creating the above-described indexes (LI_i, RI_i, CI_i), we compared them in Figure 4 to verify similarities. Since we want to test a possible common trend in price and cost variations through the selected period that could suggest a similar trend in RE market conditions, we calculated the annual variation for each index to test the analysis of variance (ANOVA) between these three groups.

Finally, we tested the mean difference of the LL_i between the two groups (GroupB and GroupA) to verify if there is a significant difference in the Land Value Ratio before and after densification.

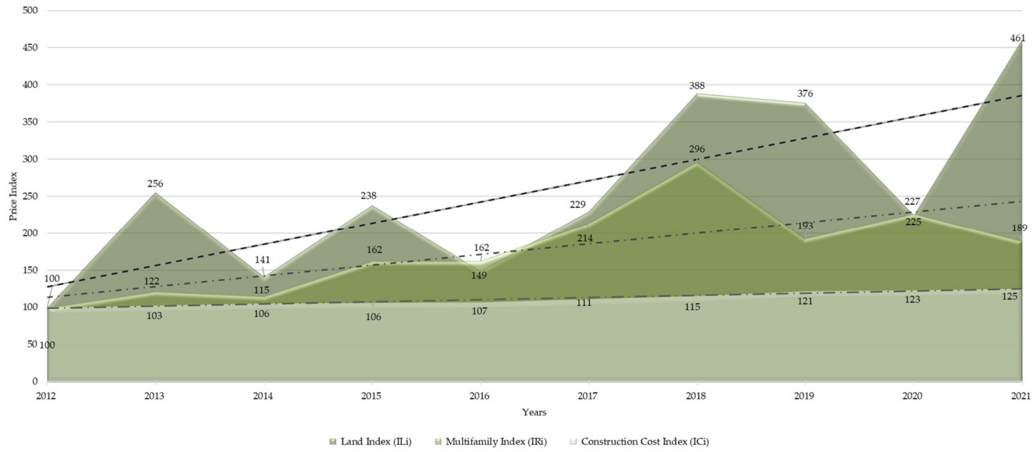

Figure 4. Land Transaction Price Index (LI_i), Residential Transaction Price Index (RI_i), and Construction Costs Index (CI_i), base: 2012. Source: authors.

4. Results and Discussion

The average Land Leverage (LL_i) within the sample stands at 35.5%, indicating that the building leverage (BL_i) is 64.5%. As summarized in Table 1 and visualized in Figure 5, the difference observed in LL_i between GroupB and GroupA amounts to 16.3%, which corresponds to the increase in the land ratio after increasing the allowable density, from an average of 32.50% in GroupB up to 37.80% in GroupA. Further, we can verify that the number of transactions increased by approximately 12.3% before and after zoning approval, with 10 average annual land sales before 2016, up to 11.08 after up-zoning tool approval, accounting for a partial year in 2022.

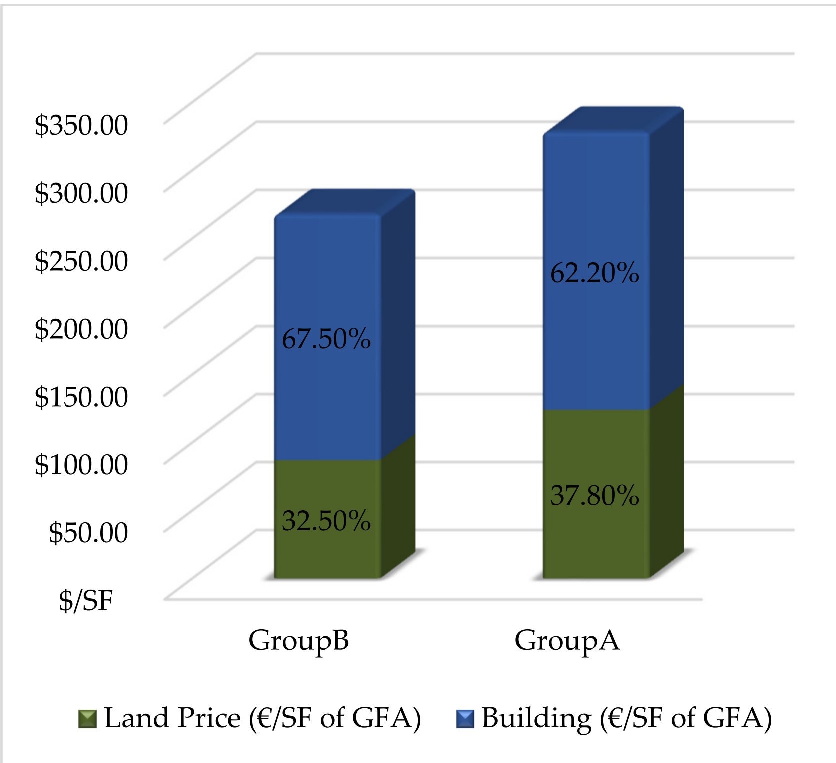

Figure 5. RE market value distribution between Land Leverage (Green) and building leverage (blue) on a USD/SF of GFA between the two groups. Source: authors.

Table 1. Descriptive statistics for LL GroupB, LL GroupA, residential prices (RP), and Construction Costs (CCs).

Variable	LLi	LLi GroupB	LLi GroupA	RP ($/SF)	CC ($/SF)
Mean	0.355	0.325	0.378	581.742	176.924
SE Mean	0.012	0.018	0.015	18.364	1.133
Median	0.348	0.320	0.357	541.821	179.300
StDev	0.127	0.113	0.125	368.197	11.988
Minimum	0.097	0.097	0.127	30.246	155.518
Maximum	0.640	0.536	0.640	2389.969	198.541
Count	112.000	40.000	72.000	402.000	112.000

The other two columns in Table 1 represent the prices (RP) and Construction Costs (CCs) that have been used to compose the Residential Transaction Index (RI_i) and the Construction Cost Index (CI_i), as per Formula (5).

Per Figure 4, which compares the trends of the three indexes that have been calculated using Formula (5), we can confirm that the Land Transaction Price Index (LI_i) increased faster than the other two indices. The Residential Transaction Price Index (RI_i), which represents RE property values (including land, improvements, and rights), increases faster than the Construction Costs Index (CI_i), but lesser than that of the Land Transaction Price Index. Since 2012, LI_i has increased by 360.9%, RI_i has increased by 89.1%, and CI_i has increased by 24.9%. When considering only the period following densification zoning approval, their respective indices have grown by 209.2%, 16.5%, and 17,1%, which corresponds to an average annual increase of 34.9% and 2.8% for RI_i and CI_i, respectively. These results suggest a notably heightened increase in the Land Transaction Price Index, which appears to be significantly impacted by densification policies. However, to verify whether the RE market trends (represented by the indexes of residential sales and construction costs) have the same growth as the land market through the selected period, we ran an ANOVA test on the annual variation for each index (LI_i, RI_i, CI_i). The *p*-value of the test rejected the null hypothesis, confirming a difference among group means of the three analyzed trends and that their variation is not correlated with an average trend (Figures 6 and 7), confirming our initial hypothesis.

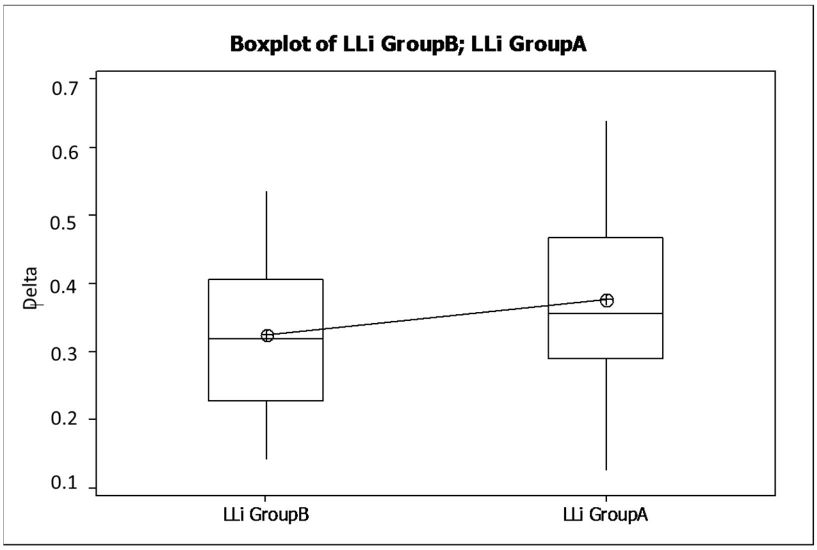

Figure 6. Boxplot of the annual variation for Land Leverage and Residential and Construction Costs Indexes (LI_i, RI_i, and CI_i).

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One-way ANOVA: Lii; RIi; Cii

Source  DF     SS      MS     F      P
Factor   2  0.569   0.284  1.47  0.250
Error   24  4.639   0.193
Total   26  5.207

S = 0.4396   R-Sq = 10.92%   R-Sq(adj) = 3.50%

                             Individual 95% CIs For Mean Based on

Level  N    Mean   StDev   -+---------+---------+---------+--------
Lii    9  0.3644  0.7146            (------------*-----------)
RIi    9  0.1044  0.2625      (-----------*-----------)
Cii    9  0.0244  0.0174    (-----------*-----------)
                            -+---------+---------+---------+--------
                           -0.25      0.00      0.25      0.50
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Figure 7. ANOVA test results of the annual variation for Land Leverage and Residential and Construction Costs Indexes (LI_i, RI_i, and CI_i).

According to the Land Leverage Hypothesis, in an RE market where residential prices have risen faster than Construction Costs (as confirmed by Figure 4), land values have increased at an even greater rate [3]. Within this market, properties with a greater LL should experience a more significant increase in price appreciation. The distribution of the LL seems to increase after densification approval, as shown in Figure 8. To corroborate this hypothesis, we ran a two-sample *t*-test between the two groups (*p*-value: 0.025; significance level: 0.05). The results of the test reject the null hypothesis of equality between the means of the two groups, endorsing the suggestion that the Land Leverage observation in GroupA is higher than LL in GroupB (Table 2). According to the performed test, the estimated difference is −0.0529, with a 95% Confidence Interval for the difference at −0.098884 −0.006964, confirming our assumptions (Figure 8).

Table 2. Two-sample *t*-test and CI: LL_i GroupB; LL_i GroupA.

	N	Mean	StDev	SE Mean
LLi GroupB	40	0.3250	0.1130	0.0180
LLi GroupA	72	0.3780	0.1250	0.0150
Difference = mu (LLi GroupB) − mu (LLi GroupA)				
Estimate for difference: −0.052924				
95% CI for difference: (−0.098884; −0.006964)				
***t*-Test of difference = 0 (vs. not =): t-Value = −2.29; *p*-Value = 0.025; DF = 87**				

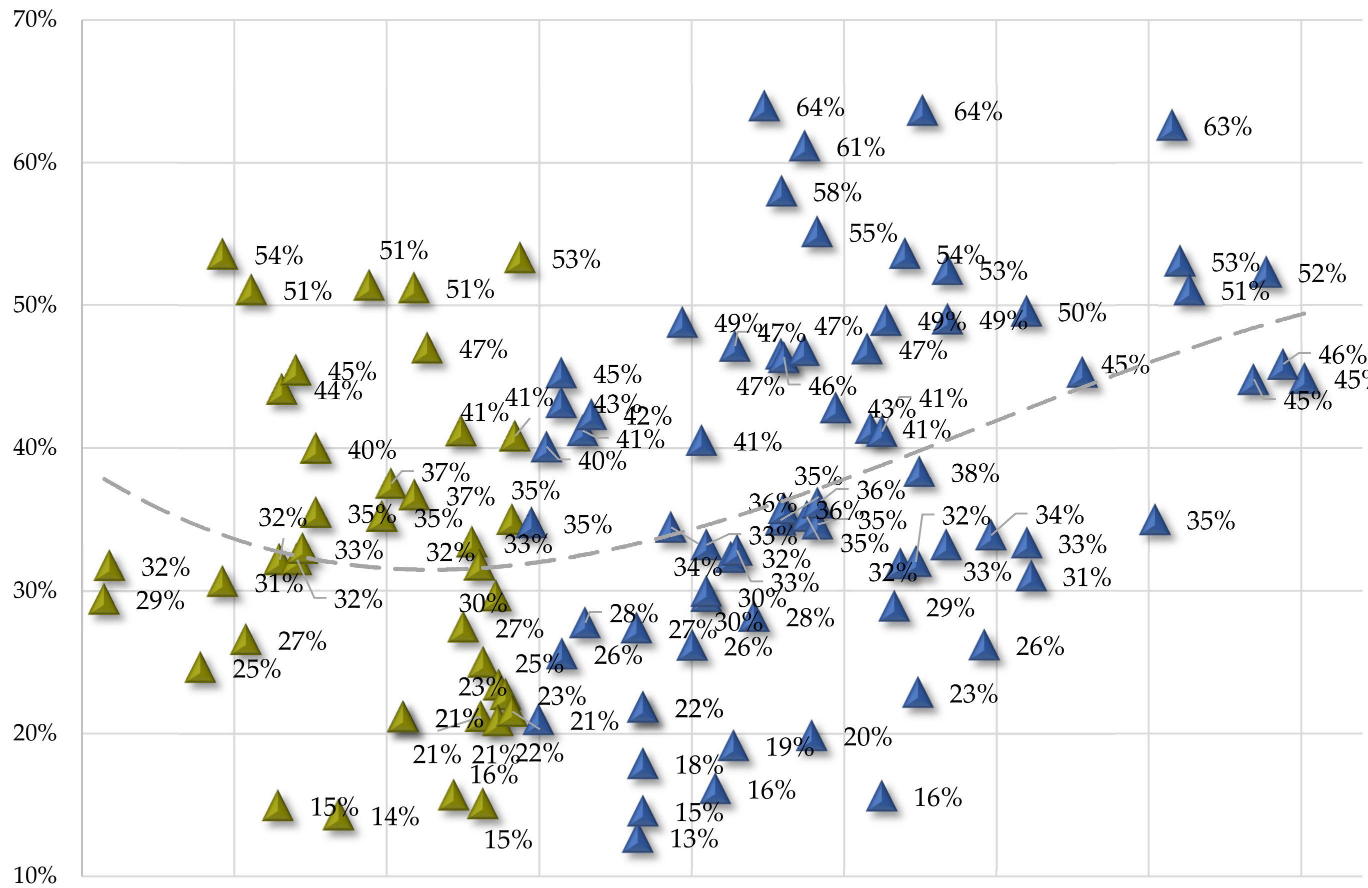

Figure 8. Land Leverage distribution. The dashed line divides the data into two groups (GroupB in green and GroupA in blue).

This outcome suggests that Land Leverage was affected by increased area densification, increasing land unit values. As land parcels are not subject to depreciation, we can assert that an increase in land value will enhance the asset's future price stability. Referring to Figures 4 and 6, it becomes evident that the LI_i has increased by approximately 3-fold compared to RI_i before the zoning change and by more than 11 times following densification approval. This confirms that land transactions have captured the highest increase in price compared to existing residential transactions. Parcels sold in GroupA, which are likely to be developed into residential assets sooner or later, will be placed on the market with a price premium in comparison to similar assets. This increase can be attributed to the Land Leverage rise, implying an increase in land value relative to the total asset value. This preliminary result is very relevant because, by changing the value ratios between the improvements and the underlying land, it stabilizes the fluctuations in the asset's value guaranteed by the underlying non-depreciable land. As is known, the depreciation of a property is attributable to physical obsolescence, external obsolescence, and functional obsolescence stemming from the aging of the improvements. The obsolescence tends to increase not only with the decrease in the residual life of the asset but also with the increase in the percentage of technology included in the improvements' physical components, which tends to depreciate much more rapidly compared to other features. Land, being inherently immune to obsolescence, does not undergo depreciation caused by age. This characteristic ensures that assets where the weight of Land Leverage is higher than others are more stable concerning market fluctuations and over time. In summary, the rise in LL in comparison to the total asset value has led to a reduced portion of the value prone to depreciation. This shift in proportions has consequently bolstered the asset's future resilience in maintaining its value over time. The parcels involved in densification have elevated the proportion of value attributed to land, thereby rendering assets more stable and less susceptible to real estate market fluctuations and future improvement obsolescence.

This outcome suggests that in high-density areas, the future depreciation in value, particularly noticeable in highly energy-efficient buildings, will exert a lesser influence on the overall fluctuation of the RE asset due to the substantial weight of the land value. Phase I of the study demonstrated a positive correlation between urban density and land value, confirming density as a value-added feature impacting land prices. Furthermore, the results from Phase II have further supported the existing correlation between Land Leverage and urban density, illustrating that denser areas possess higher leverage, enhancing asset resilience against value fluctuations and depreciation. This stability in asset value will be transferred to the forthcoming energy-efficient improvements developed on these vacant parcels. Considering that both land value and Land Leverage have increased due to densification policies, these urban planning tools will consequently influence the price appreciation and premium of the improvements built in denser areas. Considering that (i) the literature has already confirmed that EEBs achieve a market price premium [55–57,59,66,69] and that (ii) the current study has verified that density affects land prices, increasing Land Leverage, we can think that EEBs, constructed in denser areas, could benefit from an increased value resulting from these two factors. Verifying and quantifying this dual value increment will be the aim of the next step (Phase III) of our research project.

5. Conclusions

This paper shows the results obtained in Phase II of the study, investigating the possible relationship between urban density and Land Leverage. This phase demonstrated that LL increases with the potential density of the land after demonstrating correlations between land prices and densification policies in Phase I. We analyzed a time series of land sales in a restricted area of Boston, where a densification process occurred in 2016. We used 2016 as the watershed year between two moments during which permitted density underwent changes. Having established that density alterations impact the percentage composition of economic factors such as cost values, we verified how densification tools, through land values, have the potential to enhance the stability of the real estate market, reducing its susceptibility to fluctuations stemming from shifts in costs, inflation, and obsolescence of the improvements. The suggestion arose from the observation that construction costs are generally quite uniform within an RE market, and thus it must be the case that asymmetric appreciation must arise from asymmetric exposure to common shocks to land values. As Bostic et al. suggested, in the RE market, where RE prices usually rise faster than construction costs, land values rise even more, causing an increase in Land Leverage as well.

In this paper, by analyzing the LL trend over time, we have demonstrated how the level of permitted density in a neighborhood can affect LL. Such evidence will serve as the basis for the next step in our research (Phase III), where we aim to explore whether Land Leverage, facilitated by urban densification tools, could play a pivotal role in driving the values of energy-efficient assets. This finding can provide insights into various significant phenomena within the RE market, particularly those related to the evolution of prices over time. We contend that the level of land indebtedness is a crucial factor, and it enhances our comprehension of property price dynamics. The breakdown of RE prices into two separate components, such as land and improvements, is crucial as it allows these values to evolve at a different trend. This distinction also becomes necessary when studying how density, influencing Land Leverage, might affect the value of energy efficiency improvements. The values of EEBs in denser areas where Land Leverage is also higher could also be influenced by the increase in land values and in LL, as demonstrated in this study. The future steps of our research will focus on quantifying the increase in the value of EEBs built in denser areas. In the future Phase III of our research project, we aim to verify and quantify the correlation between energy-efficiency improvements valued at replacement cost minus depreciation and land values, considering that their values cannot appreciate faster than construction costs.

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