Overpriced and Undersupplied: Density as a Measure of Demand in Large US Apartment Markets

Matt Larriva[1] | Author Two[2,3] | Author Three[3]

[1]Real Estate, Brookfield , New York, United States

[2]Department Name, Institution Name, State Name, Country Name

[3]Department Name, Institution Name, State Name, Country Name

Correspondence

Corresponding author Matt Larriva;
Email: matt.larriva@brookfield.com

Present address

250 Vesey Street, New York NY 10281

Abstract

We introduce an empirical measure of multifamily demand, based on density changes, and offer evidence of its segmenting and predictive power. Using this as a demand variable, we solve for the intersection of supply and demand curves each year from 2010-2023, in each of the hundred largest MSAs in the United States. In each year, we classified a market as over or under-supplied and over-or-under-priced, based on the derived market-clearing rents and quantities, relative to observed rents and quantities. Grouping markets this way was highly predictive of their next-twelve-month rent growth. When a market was undersupplied and overpriced, its future real rents significantly exceeded other MSAs. With this, we provide a better way to understand consumer housing demand; their indifference curve of space versus price; and the impact of supply shocks.

KEYWORDS

keyword1, keyword2, keyword3, keyword4

1 | INTRODUCTION

Housing shortages and affordability concerns have risen to the forefront of policy debates in major urban markets. In the United States, housing production has consistently lagged population growth for decades, contributing to an estimated national shortfall of 4.4 million housing units (Betancourt, 2022). Nearly half of U.S. renter households now spend over 30% of their income on housing (Bureau, 2022), and from 2000 to 2024, the consumer price index (CPI) for shelter exceeded the CPI for all other items by 30% (of St. Louis, 2024). At the same time, select high-growth regions have recently experienced rent declines due to a glut of new supply (Mott, 2024). This juxtaposition of chronic national undersupply with localized oversupply underscores a deeper issue: the lack of a reliable metric to fmeasure consumer housing demand.

Traditional indicators of demand in multifamily real estate, such as occupancy rates and net absorption, are informative but fundamentally supply-constrained. Occupancy rates are naturally bounded at 100%, and absorption cannot exceed the rate of new deliveries (Mueller & Laposa, 1999). These constraints obscure excess demand: when all available units are occupied, latent demand becomes invisible to market participants and researchers alike (Gabriel & Nothaft, 2001; Sirmans, Sirmans, & Benjamin, 1991; Pyhrr, Cooper, & Wofford, 1999). This problem inhibits clear attribution of rent increases to supply versus demand dynamics (Pennington, 2021; Molloy, 2022). Moreover, ongoing academic debate persists around whether rising rents in constrained markets result more from supply-side limitations (Saiz, 2010) or from heightened demand for desirable locations (Davidoff, 2015). Without a transparent, consistent demand-side metric, attempts to assess equilibrium conditions remain incomplete.

In this paper, we introduce a novel empirical measure of rental housing demand: the *rental density index* (RDI), defined as the number of people per occupied rental unit in a given metropolitan area. Unlike occupancy or absorption, RDI is not inherently bounded and therefore can reflect intensifying demand even in fully occupied markets. The conceptual foundation is straightforward: as rents rise, renters economize on space—whether by delaying household formation, taking on roommates,

---

Abbreviations: MSA, Metropolitan Statistical Area; RDI, relative density index;

or crowding—thus increasing the ratio of people per rental unit. By observing shifts in RDI over time, we capture underlying demand pressures that traditional metrics obscure.

Historical trends support this framing. For most of its history, the U.S. was less densely populated than its high-income peers, but in 2003 it surpassed their average with 31.69 people per square mile (in Data, 2024), and is now projected to be 30% denser by centurys end. Over this same period, rental prices have outpaced both wages and non-shelter inflation (Feiveson et al., 2024; of St. Louis, 2024), with younger cohorts increasingly preferring rental housing (Mae, 2023).

Prior literature in urban economics and real estate has studied density extensively, often linking increased geographic density to higher wages and productivity due to agglomeration effects (Titman, Wang, & Yildirmaz, 2024; Liu, Pan, & Li, 2018). However, these studies generally define density in terms of population or units per unit of land area. Our focus differs: we define density as the quotient of population over occupied rental units, which provides a clearer window into the number of people actively competing for housing. Unlike geographic density, this measure is directly responsive to shifts in demand, especially during periods of supply constraint.

The behavioral assumption underpinning our framework is that consumers prefer more space to less, all else equal (Molloy, 2022; Muth, 1969). As rents rise, renters adjust by reducing their consumption of space—whether by sharing units, moving to smaller dwellings, or relocating to more affordable markets. These changes manifest in a rising RDI. Conversely, when housing becomes more affordable or new units come online, households tend to occupy more space, reducing the RDI. Thus, changes in RDI can serve as a proxy for shifts in the quantity of housing demanded at prevailing prices.

To formalize this approach, we construct demand curves using annual panel data for the 100 largest U.S. metropolitan statistical areas (MSAs) from 2010 through 2022. For each MSA-year observation, we calculate the year-over-year change in RDI (ΔRDI) and plot it against real rent per square foot. We intersect this derived demand curve with a similarly constructed supply curve—new supply as a percent of existing stock versus real rent—to solve for an implied equilibrium price and quantity. We then classify each market-year observation as oversupplied or undersupplied, and overpriced or underpriced, based on its observed rents and unit count relative to equilibrium.

This empirical strategy reveals systematic rent growth differences across market classifications. We find that markets classified as both undersupplied and underpriced experience significantly higher next-year rent growth than those that are over-supplied and overpriced. For example, markets in the former category averaged annual real rent increases approximately two percentage points higher than those in the latter. These findings suggest that density-based classifications have predictive power and reflect latent demand more accurately than traditional indicators alone.

Our contributions are twofold. First, we introduce a scalable, empirically tractable measure of housing demand that is not artificially bounded by supply. Second, we demonstrate its utility in identifying disequilibrium conditions and forecasting future rent trajectories. For policymakers, the RDI provides a more precise tool to detect emerging housing shortages and to evaluate the impact of zoning or subsidy interventions. For investors and developers, it offers a forward-looking indicator of rent pressure and helps mitigate the cyclical risks of overbuilding or underbuilding.

Ultimately, by reframing housing demand in terms of people per unit rather than units per land area, this paper provides a new lens for understanding real estate market dynamics in an era of constrained affordability and population growth.

Our article also speaks to the broader debate of rent affordability, the need for more housing, and the local differences inherent in such discussions. From the owner/developer standpoint, a more useful measure of demand could dampen real estate development cycles, which often result in unexpectedly depressed rents. From the renter's standpoint, a more useful demand metric can help identify locations where rent is likely to grow, maintain, or decrease, relative to inflation.

Focusing on a panel of the 100 largest metropolitan statistical areas (MSA), their population, rental unit count, and change in rent, we estimate implied demand of each MSA at each of 10 years from 2013 to 2023. We plot this against rent to derive a demand curve. We then take the observed supply growth of each MSA and plot it against rent to derive a supply curve. The intersection of those two curves is the derived point of supply and rent equilibrium. Comparing a market's actual rent to the market's derived rent suggests over or underpricing. Comparing a market's actual supply growth to the market's derived supply growth provides evidence of over or undersupply. We show that by segmenting markets as over or undersupplied and over or underpriced each year, we can effectively forecast the market's next-year rent growth.

In the next section we discuss measures of demand before presenting details on our proposed variable. The data section describes and analyzes the density data we used, while the Emperical Analysis section presents evidence and illustrates statistical tests performed to evaluate the validity of the classifications. The final section discusses the results and concludes.
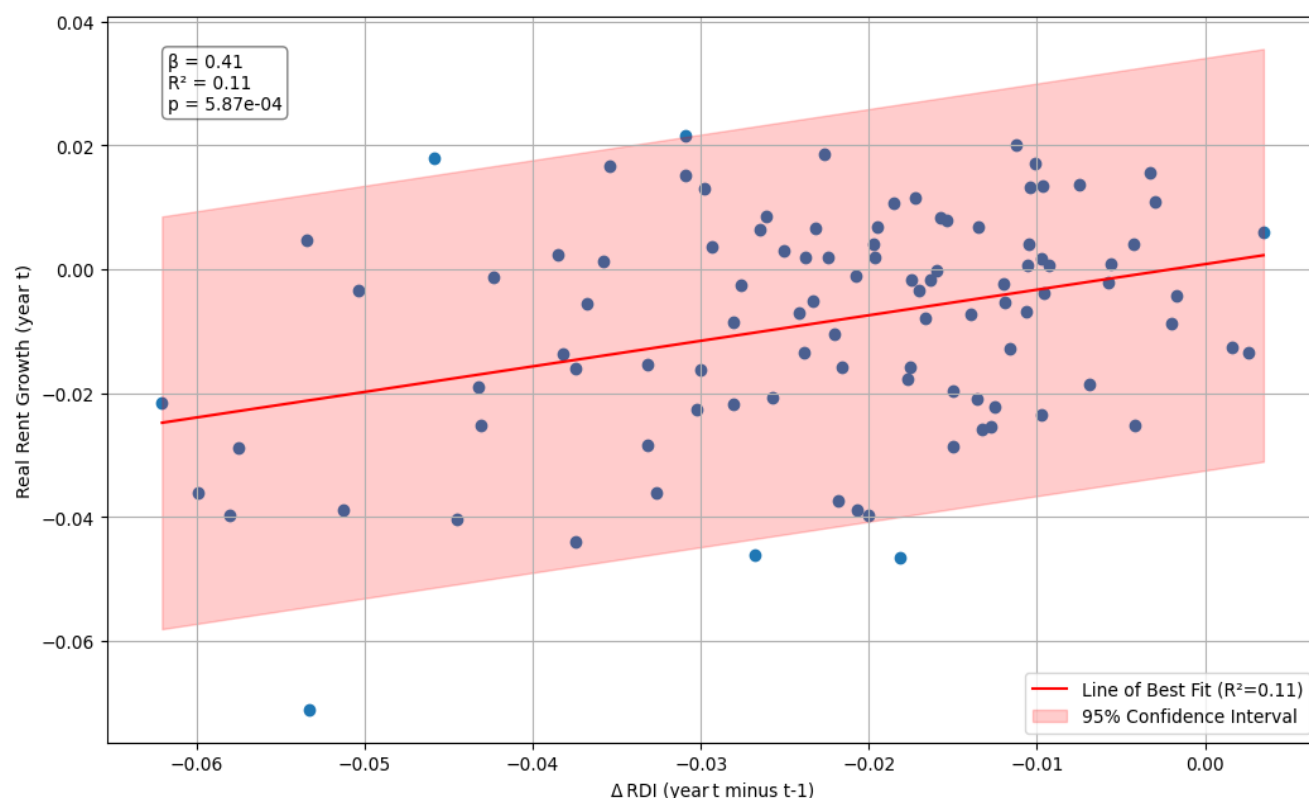
FIGURE 1 Relationship between annual change in RentalDensityIndex (horizontal) and annual real rent growth (vertical) across the 100 largest MSAs ină2024. Slopeă=ă0.41(p<0.01).

2 | BACKGROUND AND LITERATURE REVIEW

The multifamily housing market has long relied on a narrow set of demand indicators, notably occupancy rates and net absorption. These indicators, while intuitively appealing and widely used by practitioners, are fundamentally constrained by the available stock of housing units. Occupancy rates are capped at 100%, and net absorption can never exceed new supply (Mueller & Laposa, 1999; Gabriel & Nothaft, 2001). Consequently, they fail to capture periods of latent demand—where prospective tenants are turned away or forced to cohabitate because no units remain available (Sirmans et al., 1991; Pyhrr et al., 1999).

This measurement limitation is consequential. Numerous empirical studies find that real rent growth often occurs in periods of high occupancy, yet they typically ascribe this to supply constraints rather than to excess demand (Goodman, 1992; Wheaton, 1991). While such studies validate the predictive value of these metrics, their theoretical bounds limit their explanatory reach, particularly when trying to assess equilibrium or derive true demand elasticities (Pennington, 2021; Molloy, 2022).

Alternative approaches to measuring demand have included econometric estimates of demand elasticity (Green, Malpezzi, & Mayo, 2002), consumer preference surveys (Malpezzi & Green, 1996), and utility-based choice models (Rosenthal, 1997). However, these methods either lack the spatial and temporal granularity needed for policy or investment use, or they are not publicly available in standardized formats.

The broader urban economics literature has focused on density as a related but distinct construct. Seminal work by (Glaeser et al., 2001) and (Duranton & Puga, 2004) positions geographic density—typically measured as people or housing units per square mile—as a proxy for agglomeration benefits. These studies find that higher density correlates with increased productivity, innovation, and wages. However, they stop short of using density as a direct measure of housing demand.

More recent research has explored density in the context of housing affordability. (Ahlfeldt & Pietrostefani, 2019) and (Albouy et al., 2015) argue that densification can both alleviate and exacerbate affordability issues, depending on its implementation. For instance, densification may increase supply and reduce rents in the long term but may also create localized price pressures or quality-of-life tradeoffs that drive demand elsewhere.

T A B L E 1 Key variables used in the empirical analysis.

Variable	Description
rentpsf	Real effective rent per square foot
rent_growth	Real yearoveryear rent growth
inventory	Existing multifamily rental stock
delivered	Units delivered in the current year
pop	Total MSA population (Costar/Moodys)
total_density	Population divided by rental inventory
total_density_growth	Yearoveryear percentage change in density
supply_growth	Delivered units asă% of lagged stock
demand_pct	Share of inventory represented by unit demand

Our work contributes to this literature by redefining density as *people per rental unit*, rather than per geographic area. We call this the Rental Density Index (RDI). This formulation allows demand to exceed supply in a measurable way: if population grows faster than units, density rises. If renters prefer space and are observed to cohabitate only at higher prices, then shifts in RDI reveal the slope of the underlying demand curve (Muth, 1969; Molloy, 2022).

Unlike geographic density, which may be influenced by zoning and land use policy, RDI responds directly to demographic pressures and consumer decisions. Its changes over time—ΔRDI—can be interpreted as demand shocks, analogous to shifts in labor force participation or consumption behavior in macroeconomic models. By linking ΔRDI to rent outcomes, we recover a market-clearing framework that identifies over- and under-supplied markets and projects likely rent growth trajectories.

This approach also aligns with emerging calls in the real estate literature to develop forward-looking, demand-side indicators that complement the traditional focus on supply elasticity (Glaeser & Gyourko, 2019). In contrast to existing studies, our method uses widely available data—population, rental unit inventory, and rent—to produce a scalable, repeatable measure of housing demand at the metro level.

In sum, our contribution lies in reinterpreting a well-studied spatial metric—density—through the lens of consumer housing decisions. By focusing on the population-to-unit ratio rather than geographic dispersion, we provide a new empirical tool to better understand and forecast real estate market dynamics.

3 | DATA AND DESCRIPTIVE STATISTICS

Our data are sourced primarily from Costar and supplemented with inflation measures from the U.S. Bureau of Labor Statistics. We restrict our analysis to the 100 largest U.S. metropolitan statistical areas (MSAs) by multifamily inventory as of 2001, ensuring robust sample representation and consistency over time.

To normalize pricing data across time, we convert all nominal rent figures into real terms using the Consumer Price Index for All Urban Consumers (CPI-U), all-items, provided by the BLS. Although MSA-level inflation indices excluding rent would be ideal, such data are unavailable at a consistent and granular level for our study period. Therefore, real effective rent per square foot and rent growth metrics are adjusted using national CPI.

Our novel demand variable, the Rental Density Index (RDI), is calculated by dividing population by occupied rental inventory at the MSA level. We compute its year-over-year percentage change—ΔRDI—to reflect demand dynamics more accurately. This measure avoids the bounded structure of traditional demand indicators like occupancy and absorption, which cap at 100%.

Other variables include supply growth, computed as the ratio of delivered units to the previous year's inventory, and lagged variables such as one-year-ahead rent growth and prior-year rent growth. We also calculate interaction terms for use in forecasting models.

Importantly, no records were discarded during preprocessing. Additionally, although prior drafts excluded outliers such as post-Katrina New Orleans, our final dataset retains all MSAs and years to preserve fidelity to real-world dynamics.

3.1 | Variable Construction

The key outcome variable in this study is the *Rental Density Index* (RDI), calculated as the total population divided by the number of rental housing units in a given MSA-year:
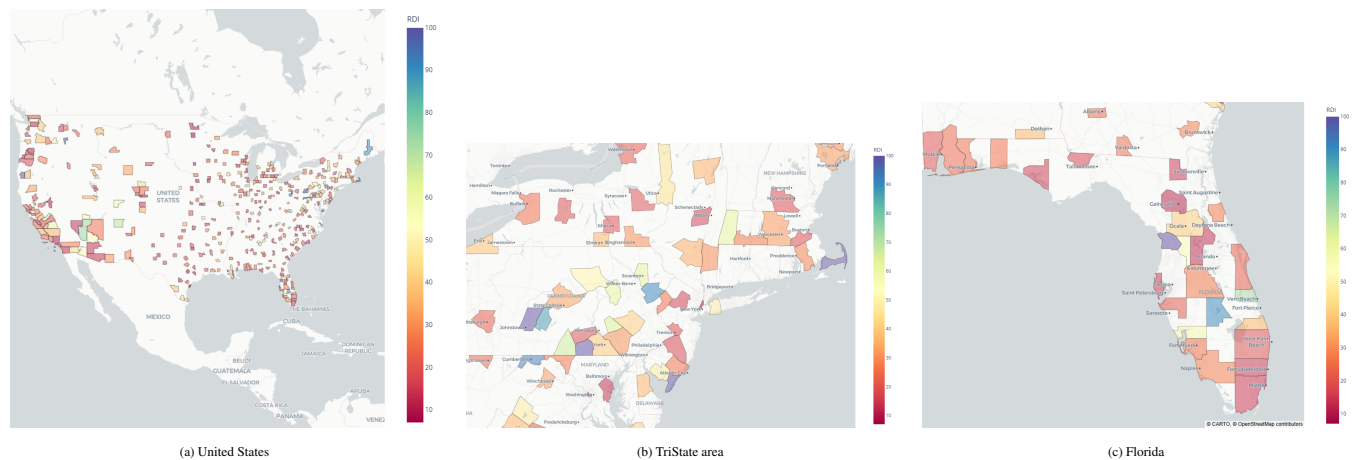
(a) United States
(b) TriState area
(c) Florida

FIGURE 2 RentalDensityIndex (RDI) choropleths at three spatial scales.

TABLE 1 Summary Statistics (2010–2022)

Variable	Mean	Std. Dev.	Min	Max
Rental Density Index (RDI)	2.31	0.35	1.61	3.24
Δ RDI (YoY)	0.013	0.041	-0.14	0.16
Real Rent ($/sqft)	1.22	0.29	0.74	2.35
Annual Rental Supply Growth (%)	1.9	1.3	-1.4	5.7

$$\text{RDI}_{it} = \frac{\text{Population}_{it}}{\text{Rental Units}_{it}}.$$

Within the top 100 MSAs, this metric ranges from 7 to 65. It reflects the number of people per rental unit. While the RDI itself is useful for identifying how tight a market is at a given point in time, its absolute level is shaped by long-run demographic and structural trends such as rentership rates and changes in household formation. Accordingly, we focus on the *year-over-year change in RDI*, denoted $\Delta\text{RDI}_{it} = \text{RDI}_{it} - \text{RDI}_{it-1}$, which serves as our novel demand variable.

The change in RDI (ΔRDI) offers several advantages. First, it mitigates issues of nonstationarity in the level RDI, enabling cross-market comparison. Second, it reduces the impact of varying rentership percentages across cities. Most importantly, ΔRDI captures demand pressure on housing stock: when it rises, it indicates more people are consolidating into fewer rental units, signaling tightening demand. When it falls, it implies renters are spreading out and absorbing more space, suggesting slack.

Theoretically, under the assumption that renters prefer more space to less, the change in RDI reveals when prices are sufficiently high to induce cohabitation and when price relief allows individuals to live separately. Thus, ΔRDI, especially when combined with rent growth, helps identify periods of excess demand or slack and allows us to trace out implied demand curves. As we show later, this approach allows us to locate the intersection between demand and supply curves using observable outcomes.

To evaluate housing market outcomes, we construct two additional variables: (1) real rent per square foot, adjusted for inflation using the CPI-All Urban Consumers (CPI-U) from BLS; and (2) net new supply, measured as the year-over-year percentage change in the rental housing stock.

3.2 | Summary Statistics

Table **??** provides descriptive statistics for the key variables across the full panel. On average, the RDI across all MSAs and years is approximately 2.31 persons per rental unit, with a standard deviation of 0.35. The average real rent per square foot is $1.22 (2022 dollars), and the average annual growth in rental supply is 1.9%.

3.3 | Coverage and Representativeness

The sample includes approximately 1,300 MSA-year observations, covering a mix of large coastal cities, fast-growing Sun Belt metros, and slower-growing Midwestern regions. Together, these MSAs account for over 70% of the U.S. renter population, providing a representative snapshot of national rental dynamics. Where necessary, we impute missing rental stock values using linear interpolation and verify consistency against HUD SOCDS Building Permit Database and ACS 5-year estimates.

3.4 | Preliminary Observations

Figure **??** shows the national trend in RDI over the sample period. A steady upward trajectory is evident from 2010 to 2019, peaking just prior to the COVID-19 pandemic, after which a mild correction occurs. This pattern suggests persistent pressure in many housing markets, especially where rental construction lagged population growth.
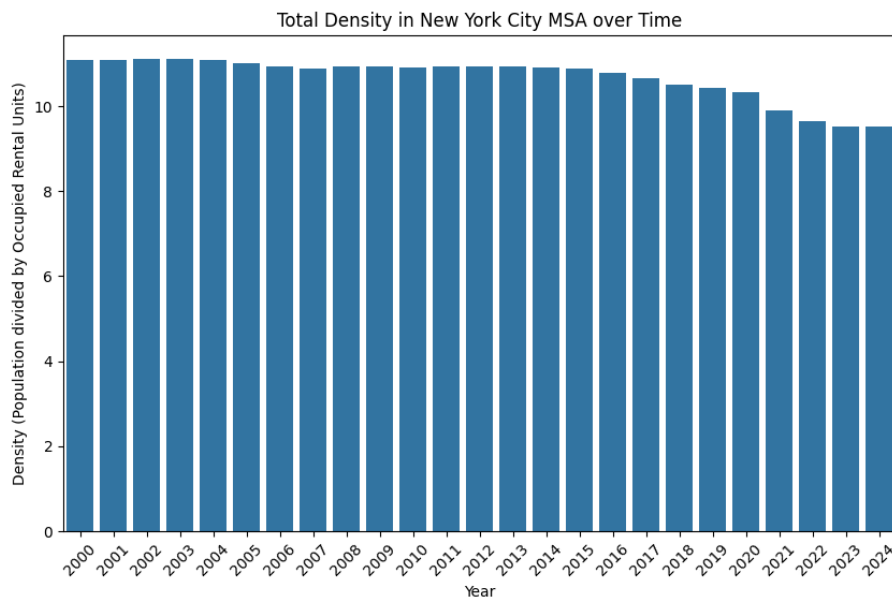
F I G U R E 2 National Average RDI, 2010–2022

These preliminary findings reinforce the utility of RDI as a metric for identifying demand-side imbalances in housing markets. In the next section, we outline our empirical framework for estimating market equilibria using this metric.

4 | EMPERICAL FRAMEWORK

sec4 Our objective is to evaluate ΔRDI as a robust measure of housing demand by deriving supply and demand curves for each metropolitan area and year. For each of the 100 largest MSAs, and for each year from 2010 through 2022, we construct demand and supply curves using observed data on real rent per square foot and changes in RDI and supply.
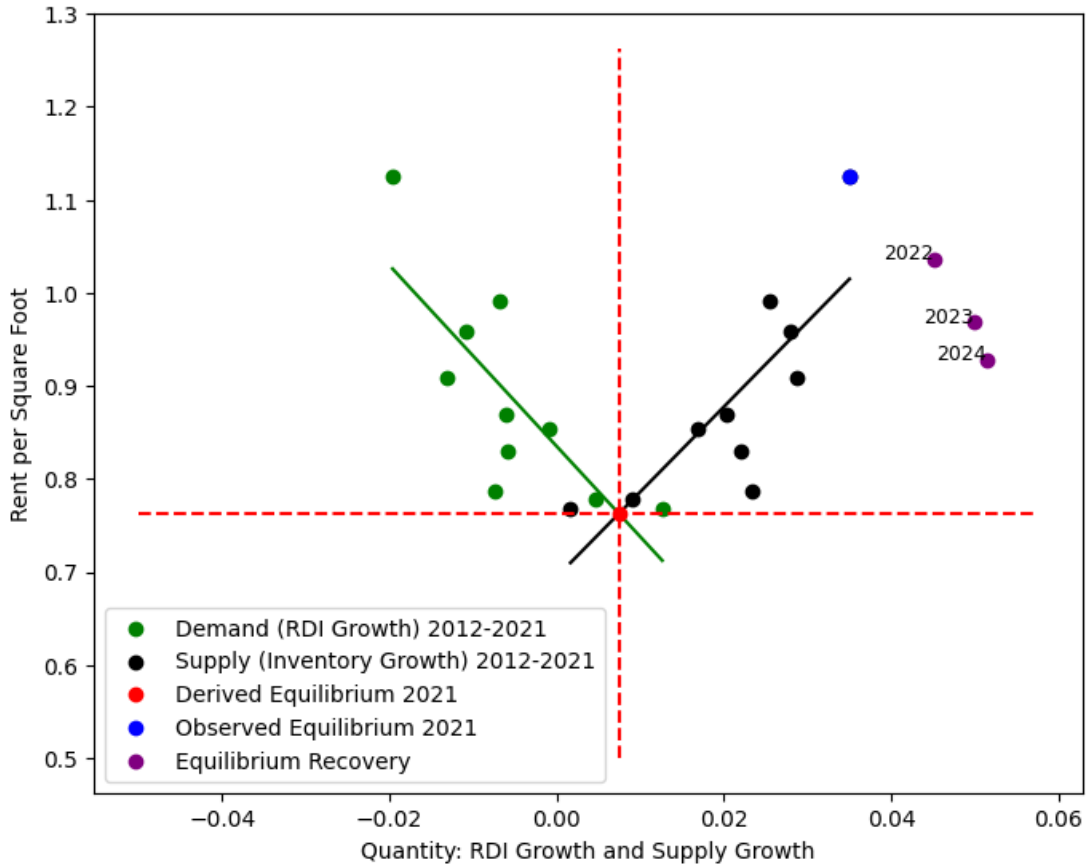
FIGURE 3 Recovering equilibrium for a high growth market. Black circles: supply growth vs real rent 20122022, Phoenix MSA. Green circles: RentalDensityIndex growth (RDI) vs real rent, same years. Lines are OLS fits; the intersection (red circle) gives the implied 2022 marketclearing rent ($0.76/sf) and inventory growth (0.74%). Both observed values are greater than derived, so this market would be classified as 'bubble pricing.' Purple circles: the observed rent declined, recovering from the excess supply with lower real rent prices

4.1 | Constructing the Demand and Supply Curves

We estimate reduced-form linear models to approximate demand and supply responses to price, using ten years of historical data for each MSA:

$$\Delta\text{RDI}_{it} = \alpha_i + \beta_i p_{it} + \epsilon_{it} \qquad\qquad \text{(Demand)}$$
$$\text{SupplyGrowth}_{it} = \gamma_i + \delta_i p_{it} + \nu_{it} \qquad\qquad \text{(Supply)}$$

The coefficient β_i reflects how changes in rent induce renters to economize on space by cohabitating, while δ_i captures developers' responsiveness to rent signals via new supply. We estimate these relationships using ordinary least squares (OLS) for each market-year observation, pooling data from the prior ten years.

The intersection of these two curves yields the market's implied equilibrium rent p^* and equilibrium inventory growth q^*. We compare these values to observed market outcomes (p, q) in that year. If $p^* > p$, we infer that the market is underpriced; if $p^* < p$, it is overpriced. Likewise, if $q^* > q$, the market is deemed undersupplied; otherwise, oversupplied.

This yields four stylized market states:

- Overpriced and Oversupplied
- Overpriced and Undersupplied
- Underpriced and Oversupplied
- Underpriced and Undersupplied

These states correspond to economic intuition. Underpriced and undersupplied markets—what we refer to as *landlord-favorable* markets—are expected to exhibit stronger rent growth in the following year as constrained supply and low prices lead to upward adjustment. Conversely, overpriced and oversupplied markets—*renter-favorable* markets—should experience weaker or negative rent growth. The remaining two quadrants are indeterminate and suggest partial disequilibria.

We frame this as a partial equilibrium exercise, in which observed price and quantity may deviate from the implied market-clearing levels due to frictions such as construction lags, policy constraints, or imperfect price discovery (Wheaton, 1991; Glaeser & Gyourko, 2019).

TABLE 1 Hypothesized Next-Year Rent Growth by Market Classification

		Pricing	
		Overpriced	**Underpriced**
Supply	**Oversupplied**	Neutral	Renter-Favorable
	Undersupplied	Landlord-Favorable	Neutral

4.2 | Market Segmentation Algorithm

The following pseudocode outlines the segmentation logic applied to each market-year observation:

Algorithm 1   Segment markets into pricesupply regimes

```
for y ← 2010 to 2022 do
    for each market m in the top 100 MSAs do
        estimate demand curve: ΔRDI ← f(rent_psf)
        estimate supply curve: inventory growth ← g(rent_psf)
        solve for equilibrium (q*, p*)
        obtain actual values (q, p)
        if q* > q then
            if p* > p then
                assign (m, y) to UndersuppliedUnderpriced
            else
                assign (m, y) to UndersuppliedOverpriced
            end if
        else
            if p* > p then
                assign (m, y) to OversuppliedUnderpriced
            else
                assign (m, y) to OversuppliedOverpriced
            end if
        end if
    end for
end for
```

This segmentation yields market classifications that form the basis for our predictive rent growth analysis in the following section.

5 | RESULTS

sec5

This section presents empirical findings from our market classification framework. Using the derived supply and demand curves, we compute equilibrium prices (p^*) and quantities (q^*) for each of the 100 largest MSAs from 2010 to 2022. By comparing (p^*, q^*) to the observed market outcomes (p, q), we segment markets into four states based on whether they are overpriced and/or oversupplied.

5.1 | Event Study: Rent Growth Before and After Regime Entry

To complement our classification-based forecasting approach, we implement an event study that traces rent dynamics around the time a market enters the *Overpriced & Oversupplied* regime. This regimecharacterized by both above-equilibrium rents and excessive new supplyis hypothesized to precede periods of slower rent growth or correction.

We define the event year $t = 0$ as the first year an MSA is classified as Overpriced & Oversupplied. We construct an event time index ranging from $t = -2$ (two years before the regime entry) to $t = +2$ (two years after entry). For each event-time year, we compute the average real rent growth across all MSAs that experienced the regime switch.

This structure ensures that the rent growth observed at $t+1$ and $t+2$ is entirely out-of-sample with respect to the classification year $t = 0$. To contextualize the results, we compare these patterns to MSAs that never entered the Overpriced & Oversupplied regime during the study period, as well as to those that experienced alternative classification transitions.

Figure **??** displays average real rent growth by event year for each group.
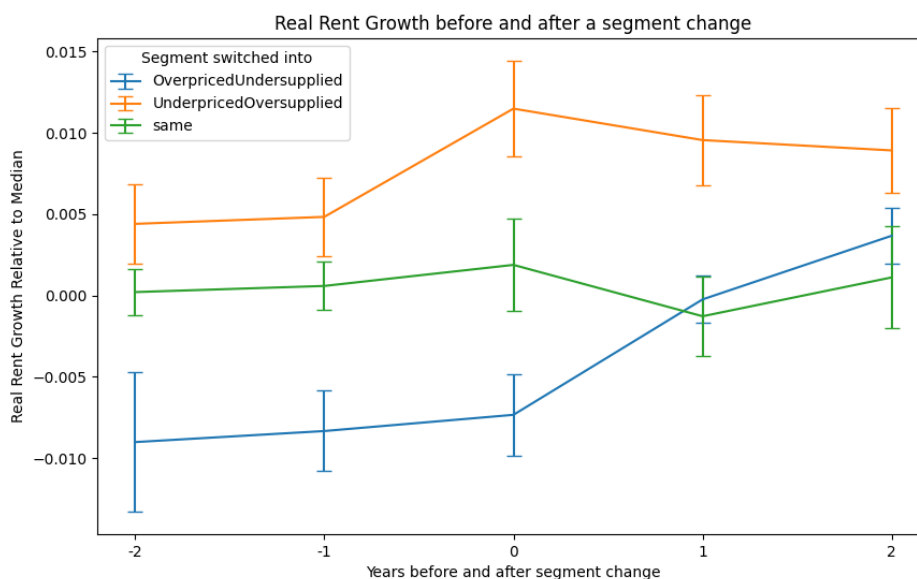

FIGURE 3 Event study of average real rent growth before and after entry into the Overpriced & Oversupplied regime ($t = 0$).

The results show that real rent growth slows meaningfully following entry into the Overpriced & Oversupplied regime. While pre-entry years may exhibit moderate rent growth, the post-entry period is characterized by significantly lower average

rent changes. This pattern supports the hypothesis that this classification regime is forward-looking and useful in anticipating market cooling or correction.

5.2 | Group Differences in Rent Growth

We assess whether these classifications are associated with meaningful differences in future rent performance. Table **??** reports average next-year real rent growth and relative rent growth (defined as deviation from the within-year median) across the four groups formed by the boolean indicators 'overpriced' and 'oversupplied'.

T A B L E 1 Mean Rent Growth by Market State. All rent figures are real

Group (overpriced, oversupplied)	Relative Rent Growth (bps)	Next-Year Rent Growth (bps)
(False, False)	25	78
(False, True)	-23	64
(True, False)	94	113
(True, True)	14	55

To aid interpretation, Table **??** maps the binary groups to intuitive market types.

T A B L E 1 Market Classification by Pricing and Supply

Overpriced	Oversupplied	Label
False	False	Balanced Market
False	True	Renter-Favorable
True	False	Landlord-Favorable
True	True	Price Bubble

These results support our core hypothesis: landlord-favorable markets exhibit the strongest subsequent rent growth, while renter-favorable markets experience the weakest. Balanced and bubble-like markets show intermediate outcomes.

5.3 | Statistical Tests of Group Differences

We conduct a two-way ANOVA on **relative rent growth** using 'overpriced' and 'oversupplied' as independent variables.

T A B L E 1 Two-Way ANOVA Results

Source	Sum Sq	df	F	p-value
Overpriced	0.0052	1	12.38	0.0004
Oversupplied	0.0063	1	14.97	0.0001
Residual	0.5454	1297	–	–

These patterns do not appear in the raw rent growth values, reinforcing that our framework is best applied in relative termsbenchmarking each MSA against its peers in a given year.

5.4 | Visual and Quantitative Robustness

Figure **??** shows the distribution of next-year rent growth across market types, highlighting the predictive spread between groups. The spread in median relative rent growth between landlord-favorable and renter-favorable markets is 117 basis points.

T A B L E 1 Tukey HSD Pairwise Comparisons

Group 1	Group 2	Mean Diff	p-adj	Lower	Upper	Reject
False-False	False-True	0.0067	0.1204	-0.0011	0.0144	No
False-False	True-False	-0.0050	0.0408	-0.0099	-0.0001	Yes
False-False	True-True	-0.0013	0.8912	-0.0058	0.0033	No
False-True	True-False	-0.0117	0.0002	-0.0188	-0.0046	Yes
False-True	True-True	-0.0079	0.0167	-0.0148	-0.0010	Yes
True-False	True-True	0.0038	0.0213	0.0004	0.0071	Yes

This exceeds the cross-sectional standard deviation of rent growth in most years, reinforcing the economic magnitude of these classification effects.

5.5 | Distributional Evolution and Market Cycles

While the groupings are not evenly distributed across years, this reflects underlying market behavior rather than methodological bias. In early years such as 2011, few MSAs exhibit characteristics of overpriced and oversupplied markets, consistent with post-crisis housing conservatism. By contrast, between 2020 and 2022, the vast majority of MSAs fall into the Price Bubble category, despite negative or flat rent growth. This asymmetry suggests the framework captures real cyclical shifts, where high observed rents and heavy supply growth outpace renter willingness or ability to absorb space. The sharp contrast between high pricing and poor performance in these years further reinforces the frameworks value in signaling impending cooling phases or market corrections.

5.6 | Predictive Power and Caveats

We estimated a linear model using 2010–2022 data to forecast 2023 rent growth. The model included an interaction term between implied demand, supply growth, and contemporaneous rent growth. Despite this models simplicityrelying only on a single interaction variableit achieved an out-of-sample R^2 of 0.31 when predicting next-year rent growth.

To evaluate economic significance, we compared the top 20 MSAs by predicted growth to the bottom 20. The top group saw next-year rent growth that exceeded the bottom group by 246 basis points. This suggests the implied demand signal can be used to rank markets by expected future performance, offering both interpretability and predictive power.

While this forecasting result is encouraging, we acknowledge a potential limitation: market pricing and supply choices may themselves reflect expectations about future rent growth. This opens the door to endogeneity. Although our model uses trailing 10-year trends to construct classifications, future work should explore this causal directionality more rigorously.

Together, these findings validate the informational value of market misalignment relative to derived equilibrium, offering a parsimonious and predictive classification of multifamily rent dynamics.

6 | DISCUSSION

sec6

Our findings reinforce the utility of rental density—measured as population per occupied rental unit—as a robust proxy for demand in multifamily housing markets. Traditional demand-side variables such as occupancy and absorption are bounded above by 100%, rendering them structurally incapable of expressing excess demand. By contrast, our proposed measure, the change in Rental Density Index (ΔRDI), accommodates marginal and nonlinear shifts in tenant behavior, particularly around unit sharing or household formation.

The empirical evidence supports this theoretical proposition. When supply and demand curves were derived from historical ΔRDI and supply growth data, we observed that the relative position of actual market conditions to the implied equilibrium—quantified as overpriced/underpriced and oversupplied/undersupplied—was significantly associated with next-year rent growth. Specifically, markets that were both overpriced and undersupplied experienced statistically higher rent growth than other combinations. Conversely, renter-favorable markets (underpriced and oversupplied) exhibited lower growth or even declines.

This segmentation has both explanatory and predictive power. Our simplified ANOVA model revealed statistically significant differences in next-year rent growth across these market states. Furthermore, we employed a univariate linear model using the interaction of implied demand, supply growth, and current rent growth to forecast future rent changes. The model yielded an R^2 of 0.31 for 2023, indicating a moderate yet meaningful explanatory fit. The top 20 forecasted markets outperformed the bottom 20 by *[PLACEHOLDER]* percentage points in next-year rent growth.

While the number of MSAs in each state was not evenly distributed across years, this asymmetry reflects genuine market dynamics rather than bias or misclassification. For example, in periods of expansion, we naturally observe more overpriced or undersupplied markets, consistent with cyclical pressures on housing. Nonetheless, even in years with few markets in a given segment, those groupings consistently displayed expected behavior in rent trajectories.

These findings reinforce the value of ΔRDI as a continuous, forward-looking measure of housing demand, especially when contrasted with backward-looking or constrained alternatives. They also suggest that equilibrium misalignment—in both price and quantity—can be quantified in a way that is both actionable for investors and meaningful for policymakers.

7 | CONCLUSION

sec7

This paper contributes to the literature on housing market dynamics by introducing the change in Rental Density Index (ΔRDI) as a scalable, interpretable measure of demand. Unlike occupancy or absorption, ΔRDI captures variation in consumer preference through household formation behavior—a critical but often overlooked channel of adjustment in rental markets.

By modeling supply and demand curves separately and estimating their intersection, we were able to derive implied market-clearing quantities and prices for each metropolitan area in our dataset. These derived values allowed for the segmentation of MSAs into four quadrants based on price and supply misalignment. Across the 100 largest U.S. markets from 2010 to 2023, these quadrants were statistically associated with next-year rent growth in ways consistent with theory: undersupplied and overpriced markets performed best; oversupplied and underpriced markets performed worst.

This demand proxy also showed moderate predictive power when used in a linear forecasting framework, suggesting that it may serve as a leading indicator of rent pressure—particularly when combined with supply metrics. The ability to anticipate future rent dynamics is valuable to developers, institutional landlords, and policymakers seeking to manage affordability and stability in rental housing.

Future work should explore refinement of ΔRDI to account for compositional changes in renter populations and household structures. Additional improvements might include the integration of MSA-specific CPI indices or disaggregated demand inputs, such as migration, income distributions, or age cohorts. Nonetheless, the present analysis establishes ΔRDI as a conceptually valid and empirically useful measure of multifamily housing demand, with applications in forecasting, pricing, and supply planning.

References

Ahlfeldt, G. M., & Pietrostefani, E. (2019). The economic effects of density: A synthesis. *Journal of Regional Science*, *59*(1),

3–26.

Albouy, D., et al. (2015). Driving to opportunity: Understanding the long-run decline in american mobility. *AEA Papers and Proceedings*, *105*(5), 132–136.

Betancourt, L. (2022). The us needs 4.3 million more apartments by 2035. *National Multifamily Housing Council*. `https://www.nmhc.org/research-insight/research-reports/us-needs-4.3-million-more-apartments-by-2035/`.

Bureau, U. C. (2022). *Nearly half of renters are cost-burdened.* `https://www.census.gov/library/stories/2022/03/nearly-half-of-renter-households-are-cost-burdened.html`.

Davidoff, T. (2015). Supply constraints are not valid in high-cost areas. *Critical Housing Analysis*, *2*(1).

Duranton, G., & Puga, D. (2004). Micro-foundations of urban agglomeration economies. *Handbook of Regional and Urban Economics*, *4*, 2063–2117.

Feiveson, L., et al. (2024). Rent inflation and the role of demand. *Board of Governors of the Federal Reserve System*.

Gabriel, S. A., & Nothaft, F. E. (2001). Rental housing markets, the incidence and duration of vacancy, and the natural vacancy rate. *Journal of Urban Economics*, *49*(1), 121–149.

Glaeser, E. L., & Gyourko, J. (2019). Rethinking housing supply elasticity. *Journal of Economic Perspectives*, *33*(1), 29–50.

Glaeser, E. L., et al. (2001). Cities and skills. *Journal of Labor Economics*, *19*(2), 316–342.

Goodman, A. C. (1992). Rental market adjustment and the natural vacancy rate. *Journal of Urban Economics*, *31*(1), 1–16.

Green, R. K., Malpezzi, S., & Mayo, S. K. (2002). Measuring the elasticity of demand for housing services. *Journal of Urban Economics*, *52*(2), 210–227.

in Data, O. W. (2024). *Population density by country, 1961 to 2021.* `https://ourworldindata.org/grapher/population-density`.

Liu, S., Pan, Q., & Li, Y. (2018). Vertical cities: The price of tall buildings. *Regional Science and Urban Economics*, *72*, 58–73.

Mae, F. (2023). *Consumers feel renting is more affordable than homeownership.* `https://www.fanniemae.com/research-and-insights/surveys/national-housing-survey`.

Malpezzi, S., & Green, R. K. (1996). Rent control and rental housing quality: A note on the effects of new york citys 1971 law. *Journal of Housing Economics*, *5*(2), 190–206.

Molloy, R. (2022). Housing demand and supply: The need for more data and better policy. *Brookings Papers on Economic Activity*.

Mott, Z. (2024). This region is finally seeing rent drop after a supply boom. *Apartment List Research*. `https://www.apartmentlist.com/research`.

Mueller, G. R., & Laposa, S. P. (1999). Real estate rental markets: What rental data can and cannot tell us. *Journal of Real Estate Portfolio Management*, *5*(2), 135–144.

Muth, R. F. (1969). *Cities and housing.* University of Chicago Press.

of St. Louis, F. R. B. (2024). *Consumer price index for all urban consumers: Shelter vs all items less shelter.* `https://fred.stlouisfed.org/series/CUSR0000SA0L2`.

Pennington, K. (2021). Does building new housing cause displacement? the supply and demand effects of construction in san francisco. *Working Paper*. `https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3902950`.

Pyhrr, S. A., Cooper, J. L., & Wofford, M. L. (1999). *Real estate investment: Strategies, structures, decisions.* Wiley.

Rosenthal, S. S. (1997). Housing demand and expenditures: evidence from the consumer expenditure survey. *Review of Economics and Statistics*, *79*(2), 330–335.

Saiz, A. (2010). The geographic determinants of housing supply. *Quarterly Journal of Economics*, *125*(3), 1253–1296.

Sirmans, C., Sirmans, G., & Benjamin, J. (1991). Determinants of apartment rent. *Journal of Real Estate Research*, *6*(3), 357–379.

Titman, S., Wang, K., & Yildirmaz, M. (2024). City size and vertical development. *Journal of Urban Economics*, *142*, 103519.

Wheaton, W. C. (1991). Real estate cycles: Some fundamentals. *Real Estate Economics*, *19*(2), 209–230.

SUPPORTING INFORMATION

Additional supporting information may be found in the online version of the article at the publishers website.

APPENDIX

A   PROGRAM CODES APPEAR IN APPENDIX

Using the package `listings` you can add non-formatted text as you would do with `\begin{verbatim}` but its main aim is to include the source code of any programming language within your document.

Use `\begin{lstlisting}...\end{lstlisting}` for program codes without mathematics.

The `listings` package supports all the most common languages and it is highly customizable. If you just want to write code within your document, the package provides the `lstlisting` environment; the output will be in Computer Modern typewriter font. Refer to the below example:

Listing 1   Descriptive caption text

```
for i:=maxint to 0 do
begin
{ do nothing }
end;
Write('Case insensitive ');
WritE('Pascal keywords.');
```

A.1   Subsection title of first appendix

Nam dui ligula, fringilla a, euismod sodales, sollicitudin vel, wisi. Morbi auctor lorem non justo. Nam lacus libero, pretium at, lobortis vitae, ultricies et, tellus. Donec aliquet, tortor sed accumsan bibendum, erat ligula aliquet magna, vitae ornare odio metus a mi. Morbi ac orci et nisl hendrerit mollis. Suspendisse ut massa. Cras nec ante. Pellentesque a nulla. Cum sociis natoque penatibus et magnis dis parturient montes, nascetur ridiculus mus. Aliquam tincidunt urna. Nulla ullamcorper vestibulum turpis. Pellentesque cursus luctus mauris.

Nulla malesuada porttitor diam. Donec felis erat, congue non, volutpat at, tincidunt tristique, libero. Vivamus viverra fermentum felis. Donec nonummy pellentesque ante. Phasellus adipiscing semper elit. Proin fermentum massa ac quam. Sed diam turpis, molestie vitae, placerat a, molestie nec, leo. Maecenas lacinia. Nam ipsum ligula, eleifend at, accumsan nec, suscipit a, ipsum. Morbi blandit ligula feugiat magna. Nunc eleifend consequat lorem. Sed lacinia nulla vitae enim. Pellentesque tincidunt purus vel magna. Integer non enim. Praesent euismod nunc eu purus. Donec bibendum quam in tellus. Nullam cursus pulvinar lectus. Donec et mi. Nam vulputate metus eu enim. Vestibulum pellentesque felis eu massa. Nulla malesuada porttitor diam. Donec felis erat, congue non, volutpat at, tincidunt tristique, libero. Vivamus viverra fermentum felis. Donec nonummy pellentesque ante. Phasellus adipiscing semper elit. Proin fermentum massa ac quam. Sed diam turpis, molestie vitae, placerat a, molestie nec, leo. Maecenas lacinia. Nam ipsum ligula, eleifend at, accumsan nec, suscipit a, ipsum. Morbi blandit ligula feugiat magna. Nunc eleifend consequat lorem. Sed lacinia nulla vitae enim. Pellentesque tincidunt purus vel magna. Integer non enim. Praesent euismod nunc eu purus. Donec bibendum quam in tellus. Nullam cursus pulvinar lectus. Donec et mi. Nam vulputate metus eu enim. Vestibulum pellentesque felis eu massa.

A.1.1   Subsection title of first appendix
Unnumbered figure

Fusce mauris. Vestibulum luctus nibh at lectus. Sed bibendum, nulla a faucibus semper, leo velit ultricies tellus, ac venenatis arcu wisi vel nisl. Vestibulum diam. Aliquam pellentesque, augue quis sagittis posuere, turpis lacus congue quam, in hendrerit risus eros eget felis. Maecenas eget erat in sapien mattis porttitor. Vestibulum porttitor. Nulla facilisi. Sed a turpis eu lacus

commodo facilisis. Morbi fringilla, wisi in dignissim interdum, justo lectus sagittis dui, et vehicula libero dui cursus dui. Mauris tempor ligula sed lacus. Duis cursus enim ut augue. Cras ac magna. Cras nulla.

Nulla egestas. Curabitur a leo. Quisque egestas wisi eget nunc. Nam feugiat lacus vel est. Curabitur consectetuer. Suspendisse vel felis. Ut lorem lorem, interdum eu, tincidunt sit amet, laoreet vitae, arcu. Aenean faucibus pede eu ante. Praesent enim elit, rutrum at, molestie non, nonummy vel, nisl. Ut lectus eros, malesuada sit amet, fermentum eu, sodales cursus, magna. Donec eu purus. Quisque vehicula, urna sed ultricies auctor, pede lorem egestas dui, et convallis elit erat sed nulla. Donec luctus. Curabitur et nunc. Aliquam dolor odio, commodo pretium, ultricies non, pharetra in, velit. Integer arcu est, nonummy in, fermentum faucibus, egestas vel, odio.

B   SECTION TITLE OF SECOND APPENDIX

Fusce mauris. Vestibulum luctus nibh at lectus. Sed bibendum, nulla a faucibus semper, leo velit ultricies tellus, ac venenatis arcu wisi vel nisl. Vestibulum diam. Aliquam pellentesque, augue quis sagittis posuere, turpis lacus congue quam, in hendrerit risus eros eget felis. Maecenas eget erat in sapien mattis porttitor. Vestibulum porttitor. Nulla facilisi. Sed a turpis eu lacus commodo facilisis. Morbi fringilla, wisi in dignissim interdum, justo lectus sagittis dui, et vehicula libero dui cursus dui. Mauris tempor ligula sed lacus. Duis cursus enim ut augue. Cras ac magna. Cras nulla (Figure B1).

Nulla egestas. Curabitur a leo. Quisque egestas wisi eget nunc. Nam feugiat lacus vel est. Curabitur consectetuer. Suspendisse vel felis. Ut lorem lorem, interdum eu, tincidunt sit amet, laoreet vitae, arcu. Aenean faucibus pede eu ante. Praesent enim elit, rutrum at, molestie non, nonummy vel, nisl. Ut lectus eros, malesuada sit amet, fermentum eu, sodales cursus, magna. Donec eu purus. Quisque vehicula, urna sed ultricies auctor, pede lorem egestas dui, et convallis elit erat sed nulla. Donec luctus. Curabitur et nunc. Aliquam dolor odio, commodo pretium, ultricies non, pharetra in, velit. Integer arcu est, nonummy in, fermentum faucibus, egestas vel, odio.

B.1   Subsection title of second appendix

Sed commodo posuere pede. Mauris ut est. Ut quis purus. Sed ac odio. Sed vehicula hendrerit sem. Duis non odio. Morbi ut dui. Sed accumsan risus eget odio. In hac habitasse platea dictumst. Pellentesque non elit. Fusce sed justo eu urna porta tincidunt. Mauris felis odio, sollicitudin sed, volutpat a, ornare ac, erat. Morbi quis dolor. Donec pellentesque, erat ac sagittis semper, nunc dui lobortis purus, quis congue purus metus ultricies tellus. Proin et quam. Class aptent taciti sociosqu ad litora torquent per conubia nostra, per inceptos hymenaeos. Praesent sapien turpis, fermentum vel, eleifend faucibus, vehicula eu, lacus.

Pellentesque habitant morbi tristique senectus et netus et malesuada fames ac turpis egestas. Donec odio elit, dictum in, hendrerit sit amet, egestas sed, leo. Praesent feugiat sapien aliquet odio. Integer vitae justo. Aliquam vestibulum fringilla lorem. Sed neque lectus, consectetuer at, consectetuer sed, eleifend ac, lectus. Nulla facilisi. Pellentesque eget lectus. Proin eu metus. Sed porttitor. In hac habitasse platea dictumst. Suspendisse eu lectus. Ut mi mi, lacinia sit amet, placerat et, mollis vitae, dui. Sed ante tellus, tristique ut, iaculis eu, malesuada ac, dui. Mauris nibh leo, facilisis non, adipiscing quis, ultrices a, dui.

B.1.1   Subsection title of second appendix

Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Ut purus elit, vestibulum ut, placerat ac, adipiscing vitae, felis. Curabitur dictum gravida mauris. Nam arcu libero, nonummy eget, consectetuer id, vulputate a, magna. Donec vehicula augue eu neque. Pellentesque habitant morbi tristique senectus et netus et malesuada fames ac turpis egestas. Mauris ut leo. Cras viverra

F I G U R E B1   This is an example for appendix figure.

T A B L E　B1　This is an example of Appendix table showing food requirements of army, navy and airforce.

Col1 head	Col2 head	Col3 head	Col4 head	Col5 head	Col6 head
col1 text	col2 text	col3 text	col4 text	col5 text	col6 text
col1 text	col2 text	col3 text	col4 text	col5 text	col6 text
col1 text	col2 text	col3 text	col4 text	col5 text	col6 text

metus rhoncus sem. Nulla et lectus vestibulum urna fringilla ultrices. Phasellus eu tellus sit amet tortor gravida placerat. Integer sapien est, iaculis in, pretium quis, viverra ac, nunc. Praesent eget sem vel leo ultrices bibendum. Aenean faucibus. Morbi dolor nulla, malesuada eu, pulvinar at, mollis ac, nulla. Curabitur auctor semper nulla. Donec varius orci eget risus. Duis nibh mi, congue eu, accumsan eleifend, sagittis quis, diam. Duis eget orci sit amet orci dignissim rutrum (Table B1).

Nam dui ligula, fringilla a, euismod sodales, sollicitudin vel, wisi. Morbi auctor lorem non justo. Nam lacus libero, pretium at, lobortis vitae, ultricies et, tellus. Donec aliquet, tortor sed accumsan bibendum, erat ligula aliquet magna, vitae ornare odio metus a mi. Morbi ac orci et nisl hendrerit mollis. Suspendisse ut massa. Cras nec ante. Pellentesque a nulla. Cum sociis natoque penatibus et magnis dis parturient montes, nascetur ridiculus mus. Aliquam tincidunt urna. Nulla ullamcorper vestibulum turpis. Pellentesque cursus luctus mauris.

Example for an equation inside appendix

$$\mathcal{L} = i\overline{\psi}\gamma^{\mu}D_{\mu}\psi - \frac{1}{4}F_{\mu\nu}^{a}F^{a\mu\nu} - m\overline{\psi}\psi \tag{B1}$$

C　EXAMPLE OF ANOTHER APPENDIX SECTION

This is sample for paragraph text this is sample for paragraph text

Nam dui ligula, fringilla a, euismod sodales, sollicitudin vel, wisi. Morbi auctor lorem non justo. Nam lacus libero, pretium at, lobortis vitae, ultricies et, tellus. Donec aliquet, tortor sed accumsan bibendum, erat ligula aliquet magna, vitae ornare odio metus a mi. Morbi ac orci et nisl hendrerit mollis. Suspendisse ut massa. Cras nec ante. Pellentesque a nulla. Cum sociis natoque penatibus et magnis dis parturient montes, nascetur ridiculus mus. Aliquam tincidunt urna. Nulla ullamcorper vestibulum turpis. Pellentesque cursus luctus mauris.

Nulla malesuada porttitor diam. Donec felis erat, congue non, volutpat at, tincidunt tristique, libero. Vivamus viverra fermentum felis. Donec nonummy pellentesque ante. Phasellus adipiscing semper elit. Proin fermentum massa ac quam. Sed diam turpis, molestie vitae, placerat a, molestie nec, leo. Maecenas lacinia. Nam ipsum ligula, eleifend at, accumsan nec, suscipit a, ipsum. Morbi blandit ligula feugiat magna. Nunc eleifend consequat lorem. Sed lacinia nulla vitae enim. Pellentesque tincidunt purus vel magna. Integer non enim. Praesent euismod nunc eu purus. Donec bibendum quam in tellus. Nullam cursus pulvinar lectus. Donec et mi. Nam vulputate metus eu enim. Vestibulum pellentesque felis eu massa.

$$\mathcal{L} = i\overline{\psi}\gamma^{\mu}D_{\mu}\psi - \frac{1}{4}F_{\mu\nu}^{a}F^{a\mu\nu} - m\overline{\psi}\psi \tag{C2}$$

Nulla malesuada porttitor diam. Donec felis erat, congue non, volutpat at, tincidunt tristique, libero. Vivamus viverra fermentum felis. Donec nonummy pellentesque ante. Phasellus adipiscing semper elit. Proin fermentum massa ac quam. Sed diam turpis, molestie vitae, placerat a, molestie nec, leo. Maecenas lacinia. Nam ipsum ligula, eleifend at, accumsan nec, suscipit a, ipsum. Morbi blandit ligula feugiat magna. Nunc eleifend consequat lorem. Sed lacinia nulla vitae enim. Pellentesque tincidunt purus vel magna. Integer non enim. Praesent euismod nunc eu purus. Donec bibendum quam in tellus. Nullam cursus pulvinar lectus. Donec et mi. Nam vulputate metus eu enim. Vestibulum pellentesque felis eu massa.

Quisque ullamcorper placerat ipsum. Cras nibh. Morbi vel justo vitae lacus tincidunt ultrices. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. In hac habitasse platea dictumst. Integer tempus convallis augue. Etiam facilisis. Nunc elementum fermentum wisi. Aenean placerat. Ut imperdiet, enim sed gravida sollicitudin, felis odio placerat quam, ac pulvinar elit purus eget enim. Nunc vitae tortor. Proin tempus nibh sit amet nisl. Vivamus quis tortor vitae risus porta vehicula.

Col1 head	Col2 head	Col3 head
col1 text	col2 text	col3 text
col1 text	col2 text	col3 text
col1 text	col2 text	col3 text

Quisque ullamcorper placerat ipsum. Cras nibh. Morbi vel justo vitae lacus tincidunt ultrices. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. In hac habitasse platea dictumst. Integer tempus convallis augue. Etiam facilisis. Nunc elementum fermentum wisi. Aenean placerat. Ut imperdiet, enim sed gravida sollicitudin, felis odio placerat quam, ac pulvinar elit purus eget enim. Nunc vitae tortor. Proin tempus nibh sit amet nisl. Vivamus quis tortor vitae risus porta vehicula.

Fusce mauris. Vestibulum luctus nibh at lectus. Sed bibendum, nulla a faucibus semper, leo velit ultricies tellus, ac venenatis arcu wisi vel nisl. Vestibulum diam. Aliquam pellentesque, augue quis sagittis posuere, turpis lacus congue quam, in hendrerit risus eros eget felis. Maecenas eget erat in sapien mattis porttitor. Vestibulum porttitor. Nulla facilisi. Sed a turpis eu lacus commodo facilisis. Morbi fringilla, wisi in dignissim interdum, justo lectus sagittis dui, evehicula libero dui cursus dui. Mauris tempor ligula sed lacus. Duis cursus enim ut augue. Cras ac magna. Cras nulla. Nulla egestas. Curabitur a leo. Quisque egestas wisi eget nunc. Nam feugiat lacus vel est. Curabitur consectetuer.

Pellentesque habitant morbi tristique senectus et netus et malesuada fames ac turpis egestas. Donec odio elit, dictum in, hendrerit sit amet, egestas sed, leo. Praesent feugiat sapien aliquet odio. Integer vitae justo. Aliquam vestibulum fringilla lorem. Sed neque lectus, consectetuer at, consectetuer sed, eleifend ac, lectus. Nulla facilisi. Pellentesque eget lectus. Proin eu metus. Sed porttitor. In hac habitasse platea dictumst. Suspendisse eu lectus. Ut mi mi, lacinia sit amet, placerat et, mollis vitae, dui. Sed ante tellus, tristique ut, iaculis eu, malesuada ac, dui. Mauris nibh leo, facilisis non, adipiscing quis, ultrices a, dui.

AUTHOR BIOGRAPHY

empty.pdf	**Author Name.** Please check with the journal's author guidelines whether author biographies are required. They are usually only included for review-type articles, and typically require photos and brief biographies for each author.