# Expectations and Risk Premiums in Illiquid Real Assets*

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March 27, 2026

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*We thank Steven Grenadier, Anh Le, Jacob Sagi, Changcheng Song, Richard Greeen, Spencer Couts, and participants at the Cambridge-HKU-UF Symposium and seminars at Penn State and University of Southern California for valuable comments. We gratefully acknowledge MSCI Real Assets for providing CPPI data and the Penn State Borrelli Institute for Real Estate Studies for data acquisition and financial support.

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## Abstract

We estimate income growth expectations and risk premiums for illiquid real assets by exploiting information from long-term commercial leases. Using 20 years of U.S. lease data, we construct Spot Rent Indexes that capture instantaneous rental prices and recover physical expectations from historical rent growth and risk-neutral expectations from no-arbitrage conditions. Our indexes exhibit richer dynamics than existing indicators, tracking macroeconomic episodes with greater sensitivity. Growth expectations embedded in long-term leases are considerably more stable than realized growth, especially for large leases in newer Class A properties. The wedge between physical and risk-neutral expectations reveals risk premiums that vary substantially across markets, offering new insights into illiquid asset pricing.



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# 1 Introduction

Expectations about future cash flows and risk premiums are fundamental to both theoretical and empirical asset pricing. These expectations shape not only asset allocation decisions, but also inform the full spectrum of dynamic economic choices, including consumption, investment, and the design of fiscal and monetary policy. While macroeconomic and consumer expectations have been studied extensively (e.g., Candia et al., 2023; D'Acunto et al., 2023; Liu and Palmer, 2026), producer price expectations remain understudied despite their fundamental role in price setting. As Federal Reserve Chairman Ben Bernanke noted in 2007, "Information on the price expectations of businesses...is particularly scarce."

For liquid financial assets such as stocks and bonds, asset prices reveal cash flow expectations and risk premiums (Campbell and Shiller, 1988). However, for illiquid real assets underlying financial claims, infrequent trading poses significant estimation challenges. Consequently, expectations and risk premiums for real assets remain understudied, despite real assets constituting domestic net worth: residential real estate ($33 trillion), commercial real estate ($23 trillion), and durables and intellectual property ($17 trillion) (Bodie et al., 2021). Systematic, asset-level studies of commercial real estate are particularly scarce, limited primarily to irregular surveys (e.g., National Association of Realtors, 2020) and market-aggregate price indexes (Plazzi et al., 2010).

This paper proposes a novel method to estimate income growth expectations and risk premiums for illiquid real assets without relying on transaction prices. Our framework exploits long-term lease contracts to provide timely, granular measures of spot rents, rent growth expectations, and risk premiums for commercial real estate. We first use the term structure of lease rates to isolate the instantaneous spot rent for each lease after removing lease-term effects. We then aggregate lease-specific spot rents to construct a Spot Rent Index (SRI) for office, industrial, and retail properties at national, market, and submarket levels. The historical average growth of the SRI provides unconditional growth expectations under the physical probability measure. Simultaneously, the no-arbitrage condition equating the

lease present value to the present value of stochastic spot rents (Grenadier, 1995; Clapham and Gunnelin, 2003; Jarrow, 2023) reveals growth expectations embedded in each long-term lease under the risk-neutral measure. The wedge between physical and risk-neutral expectations quantifies the risk premium embedded in lease rates, revealing the additional return investors demand for bearing rental income uncertainty.

Our dataset comprises 20 years of long-term commercial leases from CompStak across major U.S. markets: twelve cities for office, nine for industrial, and two for retail properties, plus six San Francisco Bay Area office submarkets. This multi-level structure captures heterogeneity in spot rent dynamics and expectations both across and within metropolitan areas. Each lease includes complete monthly payment schedules with escalation clauses and concessions, enabling precise calculation of lease present values, a crucial input for recovering spot rents and rent growth expectations. Unlike studies based on infrequent property transactions, our lease-based approach leverages more frequent leasing activity to measure rental market conditions and expectations in a timely manner.

We first construct the Spot Rent Index (SRI), which measures theoretical spot (zero-term) rental prices after controlling for the effects of lease term and other lease and property characteristics. Specifically, we estimate a flexible panel regression of log effective rents on lease term polynomials, lease term-interest rate interactions, property and lease characteristics, property fixed effects, and time fixed effects. Observations are weighted by market GDP. Conditional on lease term and property- and lease-specific rent shifters, the time fixed effects identify the market SRI, capturing the instantaneous service price based on new contracts. While Abramson et al. (2025) also construct a constant-quality rent index, our SRI explicitly focuses on instantaneous spot rents through a model-based approach that isolates lease-term effects, enabling recovery of forward-looking expectations embedded in lease contracts.

The SRI is substantially more volatile and more closely aligned with macroeconomic cycles than the PPI and the commercial rental index of An et al. (2016). It declined sharply during the 2008–2009 Global Financial Crisis but rose steadily through much of the 2010s

across most cities and property types. These dynamics parallel marginal rent indexes for housing (e.g., Ambrose et al., 2015, 2023; Joshua Clark, 2022; Adams et al., 2024), which capture newly contracted short-term residential rents and exhibit greater sensitivity to market conditions than the rent component of the Consumer Price Index. The SRI also exhibits substantial heterogeneity by property type and market. Post-COVID office SRIs declined more significantly in the San Francisco Bay Area and New York City, which lost population, than in growing cities such as Phoenix and Dallas-Fort Worth. Even within the San Francisco Bay Area, financial districts were hit more severely than Silicon Valley. In contrast, post-COVID industrial SRIs have been growing at an accelerating pace in most markets, particularly in Atlanta and Dallas-Fort Worth.

Using the SRI and lease-specific spot rents that account for property and lease characteristics, we estimate two measures of growth expectations. First, we estimate unconditional growth expectations and volatility of SRI under the physical probability measure by fitting a geometric Brownian motion to the long time series of market SRI. Second, we recover risk-neutral rent growth expectations embedded in each long-term lease by numerically solving a nonlinear inversion problem for the growth rate that equates the observed lease present value with the risk-neutral present value of rolled-over spot rents. Risk-neutral expectations are lower when the long-term lease value is depressed relative to the initial spot rent due to concessions such as free rent periods and tenant improvement allowances.

We contrast five-year expected rent paths with realized SRIs (e.g., Crump et al., 2016; Castle et al., 2021). Rent growth expectations vary significantly by property type, market, and lease term, but they are considerably more stable than realized SRI growth, with expectation paths flatter than actual trajectories during appreciation phases and steeper during depreciation phases. Even during the prolonged post-GFC expansion, expectations persistently underestimated actual rent growth, consistent with systematic forecast errors from oversmoothing and rigidity (e.g., Coibion and Gorodnichenko, 2012, 2015; Koch and Noureldin, 2024). This rigidity is more pronounced for larger leases in newer Class A office

properties. Demand for these leases is presumably stable and long-term, as they serve as substitutes for corporate-owned real estate. In contrast, smaller leases in lower-quality properties represent marginal demand in each market and respond sharply to market conditions, such as the post-pandemic decline in office demand.

Comparing unconditional expectations under the physical and risk-neutral probability measures reveals the unconditional risk premium, which is implicitly determined by the covariance between spot rent processes and the stochastic discount factor. The estimated rent risk premium is equivalent to the return risk premium for commercial real estate. Risk premiums vary substantially across markets, ranging from approximately zero for Washington DC office and Las Vegas industrial properties to 6.1% for Denver office and 9.1% for Dallas-Fort Worth industrial properties. They are systematically related to local economic characteristics, including the concentration of public sector tenants and the role as a regional logistics hub. These risk premiums are partly explained by rent volatility, which ranges from 2.7% for Washington DC office to 30.6% for San Diego industrial markets. Normalizing risk premiums by volatility yields the market price of risk, which varies from $-0.231$ for Washington DC office to 1.098 for San Francisco industrial markets, revealing substantial heterogeneity in how rental income uncertainty is priced across property types and locations.

To grasp the intuition behind our estimation of the risk premium, consider a simplified Gordon Growth Model applied to perpetually rolled-over short-term leases:

$$\frac{C}{r+p-g^P} = \frac{C}{r-g^Q}, \tag{1}$$

where $C$ denotes the initial lease cash flow, $r$ denotes the risk-free rate, $p$ denotes the return risk premium, and $g^P$ and $g^Q$ denote expected cash flow growth rates under the physical and risk-neutral probability measures, respectively.[1] The no-arbitrage condition implies $p = g^P - g^Q$: the risk premium equals the difference between growth expectations under the

[1]For a lease with finite term $\tau$ in continuous time, the present value is $C(r+p-g^P)^{-1}\left(1-\exp\left(-(r+p-g^P)\tau\right)\right)$, which preserves the same economic intuition.

two measures. This approach allows us to estimate risk premiums for illiquid real assets using observable lease cash flows rather than transaction prices. Note that observed cap rates do not exactly correspond to $r + p - g^P$ because the cash flow growth rate for a given property is reduced by the rent depreciation rate $\delta$. Specifically, the cap rate equals $r + p - g^P + \delta$.

Our method builds on the no-arbitrage asset pricing framework developed in the extensive literature on the lease rate term structure (e.g., Grenadier, 1995; Clapham and Gunnelin, 2003; Ambrose and Yildirim, 2008; Agarwal et al., 2011; Yoshida et al., 2016) and real options (e.g., Lambrecht, 2017; Jarrow, 2023). The core intuition mirrors bond pricing: the present value of a long-term lease must equal the present value of sequentially rolled-over short-term leases after adjusting for risk. Thus, long-term lease rates incorporate expectations of future spot rents—if short-term rents are expected to rise, long-term effective rents will be set higher.

This paper contributes to four strands of literature. First, we contribute to the growing literature on measuring firms' inflation expectations. While there is rich evidence on households' expectations (e.g., Coibion and Gorodnichenko, 2015; Malmendier and Nagel, 2016; Agarwal et al., 2022; Coibion et al., 2023), firm-level evidence remains sparse due to the costs and biases of eliciting manager expectations at scale. New surveys such as the Survey of Firms' Inflation Expectations (SoFIE) (Coibion et al., 2020a; Candia et al., 2024) have documented weakly anchored inflation expectations among firms (Candia et al., 2024) and causal effects on economic activities (Coibion et al., 2020b; Ropele et al., 2024), with recent work examining links to production decisions (Conflitti and Zizza, 2021; Kumar and Wesselbaum, 2024; Hensel et al., 2024). We propose a novel revealed-preference measure using lease contract data. Commercial real estate rents represent an important intermediate input, and expectations embedded in lease contracts offer a unique window into firms' inflation forecasts while avoiding survey response biases.

Second, we add to the literature on measuring expectations in real estate markets. Residential housing expectations are well-studied through surveys (e.g., Kuchler et al., 2023; Liu

and Palmer, 2026) and non-survey methods (Soo, 2018; Li et al., 2025). In contrast, commercial real estate lacks systematic academic surveys; private institutions (e.g., National Association of Realtors, 2020) conduct irregular, non-standardized surveys. Among non-survey approaches, Plazzi et al. (2010) apply the Campbell–Shiller decomposition (Campbell and Shiller, 1988) to cap rates to extract rent expectations, but their analysis is limited to national aggregate data. We develop granular, market-level measures of rent-growth expectations using an asset-pricing framework and detailed lease contracts. We also construct a new commercial rent index (cf. U.S. Bureau of Labor Statistics, 2011; An et al., 2016; Abramson et al., 2025), providing timely measures valuable for researchers and practitioners.

Third, we contribute to the literature on the term structure of lease rates. Starting with Grenadier (1995), researchers have applied no-arbitrage frameworks to lease contracts. Clapham and Gunnelin (2003) model the no-arbitrage condition between long-term leases and rolled-over short-term leases with stochastic cash flows and interest rates. Subsequent work incorporates upward-only adjustments (Ambrose et al., 2002), tenant credit risk (Ambrose and Yildirim, 2008; Agarwal et al., 2011; Brueckner and Rosenthal, 2025), and cancellable options (Yoshida et al., 2016). Empirically, Stanton and Wallace (2009) fit a term structure model to shopping mall data with poor results, while Gunnelin and Söderberg (2003), Englund et al. (2004), and Bond et al. (2008) use reduced-form panel regressions to estimate term structures in Stockholm, Sweden, and London. Aldana et al. (2025) employ a Kalman filter for New York and Boston office markets. Our contribution is twofold: we estimate spot rents, rent-growth expectations, and risk premiums by combining the model-based approach of Stanton and Wallace (2009) with the panel-regression framework of Gunnelin and Söderberg (2003), providing calibration inputs for future models; and we document how these parameters vary across a broad cross-section of U.S. markets, enabling precise estimation with clear structural interpretation.

Finally, we contribute to the literature on risk premiums for non-traded illiquid assets. Cochrane (2005) and Korteweg and Sorensen (2010) estimate returns for venture-backed

companies under parametric distributions; Driessen et al. (2012) estimate risk exposures and abnormal performance of private equity funds using cash flows; Seah et al. (2025) applies this to commercial real estate. Our approach differs in two respects: we estimate risk premiums directly from the wedge between physical and risk-neutral rent growth expectations ($\mu^P - \mu^Q$) embedded in lease contracts, without requiring transaction returns or fund-level data; and we provide a unified estimate of total risk premium encompassing market, liquidity, and cash-flow risk, rather than decomposing into separate components. This framework is particularly valuable for illiquid assets where transactions are infrequent and risks extend beyond systematic market exposure.

The remainder of the paper is organized as follows. Section 2 describes the data and variables used in our analysis. Section 3 presents the theoretical model and outlines the empirical methodology and identification strategy. Section 4 reports the national results for three property types, while Section 5 focuses on major U.S. markets. Section 6 provides additional discusses. Finally, Section 7 concludes.

# 2 Data

## 2.1 Data Sources

Our sample of commercial real estate leases is sourced from CompStak, a leading data platform that aggregates granular, transaction-level information on lease agreements across the United States. We use three property types that have sufficiently large sample sizes: Office, industrial, and retail. The market coverage varies by property type, with the greatest coverage for office properties.

We analyze all available markets but focus on twelve large cities for office properties: New York City, the San Francisco Bay Area, Los Angeles, Chicago, Dallas–Fort Worth, Washington DC, Phoenix, Atlanta, Boston, Denver, Houston, and San Diego. For industrial properties, we primarily analyze nine markets: The San Francisco Bay Area, Los Angeles,

Dallas–Fort Worth, Washington DC, Atlanta, San Diego, Sacramento, Las Vegas, and New Jersey. For retail properties, we analyze two markets: the San Francisco Bay Area and Los Angeles. These cities are selected because they have sufficient numbers of lease observations.

We restrict the sample to lease terms between 3 and 30 years because leases shorter than 3 years produce unreliable estimates of growth rates, as we discuss in Sectoin 3. Aldana et al. (2025) also document that lease terms tend to cluster around 3, 5, 7, 10, and 15 years, while shorter or longer term leases are rare. We also exclude leases without lease type information (e.g., gross and NNN). The final dataset comprises 151,612 office leases after trimming the top and bottom 1% of (i) lease values, (ii) contractual rent growth rates, and (iii) concession ratios, and (iv) renovation-adjusted age within each market.[2] The sample period spans 2005 to 2024. Notably, the dataset includes detailed rent schedules with precise monthly payments, enabling us to compute lease values using a discounted cash flow approach.

In addition to the lease data, we incorporate interest-rate information from the 10-year U.S. Treasury yield, obtained from the Federal Reserve Economic Data (FRED) of the Federal Reserve Bank of St. Louis. We use this benchmark long-term, risk-free rate to compute present values and to infer embedded rent-growth expectations in our empirical analysis. The monthly Treasury yield is aligned with each lease's contract month to reflect the interest-rate environment prevailing at the time the agreement was executed.

Finally, we compare our estimated SRIs with two other commercial real estate rent–related indexes. The first is the Producer Price Index (PPI) for gross rents in office, industrial, and retail properties. The PPI, published by the U.S. Bureau of Labor Statistics (BLS), provides commodity-level indexes for real estate–related services, including gross rents for these property types. The second measure is MSCI's residential Commercial Property Price Index (CPPI).

[2]We trim extreme observations rather than winsorize because our analysis involves nonlinear, model-based optimization, which can be sensitive to distortions introduced by winsorization.

## 2.2 Summary Statistics

Table 1 presents summary statistics for selected variables, with complete tables provided in Appendix C. The median lease term is approximately five years across all property types. Lease contracts typically specify the initial rent and subsequent rent escalations. The mean annual escalation rate is approximately 2% for office and industrial properties and 1% for retail properties. However, these escalation rates should not be directly interpreted as rent growth expectations, as a lower escalation rate may be paired with a higher initial rent when landlords and tenants anticipate strong market rent growth.

Beyond standard rent schedules, lease contracts also include concessions such as free rent periods and tenant improvement (TI) allowances. TI allowances represent financial support from the landlord to the tenant for customizing or upgrading the leased space. Free rent and TI allowances are more commonly offered for office properties than for industrial or retail properties, with median values of two months of free rent and $4 per square foot in TI allowances. These components are essential for accurately computing the net present value of lease cash flows.

The dataset also provides rich information on contract terms, property features, and tenant characteristics. For property features, we track unique property identifiers that allow us to control for time-invariant characteristics in our analysis. We define building age as the difference between the construction date and the transaction date. To account for renovations, we additionally construct a renovation-adjusted building age, which replaces the construction date with the renovation date when renovation information is available. We use this renovation-adjusted age to estimate the rent depreciation rate. The average renovation-adjusted building age is approximately 25 years across all property types. We also observe building class designations: Class A properties comprise 59% of office leases, 18% of industrial leases, and 5% of retail leases in our sample.

Regarding contractual terms, we observe lease dates, rent structures, various lease options, and tenant information. Importantly, the dataset distinguishes net (NNN) leases from

Table 1: **Summary Statistics (Selected Variables)**

**A: Office** (18,265 Unique Properties; 194,025 Observations)

| | Mean | SD | Min | Median | Max |
|---|---|---|---|---|---|
| Lease Term (years) | 5.06 | 3.05 | 1.00 | 5.00 | 30.00 |
| Effective Rent ($/sqft/year) | 36.11 | 19.52 | 5.28 | 31.08 | 326.31 |
| Lease Size (sqft) | 9,350.59 | 16,501.51 | 166.00 | 4,003.00 | 264787.00 |
| Annual Escalation (%) | 1.66 | 1.45 | -3.04 | 2.47 | 16.82 |
| Free Rent (months) | 2.28 | 3.32 | 0.00 | 1.00 | 37.00 |
| TI Allowance ($/sqft) | 14.53 | 26.79 | 0.00 | 0.00 | 467.00 |
| Concession Ratio (%) | 3.68 | 4.26 | 0.00 | 1.85 | 25.16 |
| Lease: NNN (1/0) | 0.13 | 0.33 | 0.00 | 0.00 | 1.00 |
| Renovation-adjusted Age (years) | 24.46 | 19.55 | 0.00 | 22.00 | 141.00 |
| Building Class: A (1/0) | 0.55 | 0.50 | 0.00 | 1.00 | 1.00 |

**B: Industrial** (18,839 Unique Properties; 71,911 Observations)

| | Mean | SD | Min | Median | Max |
|---|---|---|---|---|---|
| Lease Term (years) | 4.17 | 2.22 | 1.00 | 4.00 | 30.00 |
| Effective Rent ($/sqft/year) | 11.50 | 7.63 | 1.58 | 9.72 | 77.38 |
| Lease Size (sqft) | 34,630.26 | 68,746.19 | 638.00 | 11,902.00 | 1.00e+06 |
| Annual Escalation (%) | 1.92 | 1.54 | 0.00 | 2.96 | 13.90 |
| Free Rent (months) | 0.99 | 1.58 | 0.00 | 0.00 | 30.00 |
| TI Allowance ($/sqft) | 1.68 | 7.91 | 0.00 | 0.00 | 265.00 |
| Concession Ratio (%) | 1.95 | 2.78 | 0.00 | 0.00 | 17.26 |
| Lease: NNN (1/0) | 0.58 | 0.49 | 0.00 | 1.00 | 1.00 |
| Renovation-adjusted Age (years) | 26.69 | 14.63 | 0.00 | 27.00 | 120.00 |
| Building Class: A (1/0) | 0.15 | 0.36 | 0.00 | 0.00 | 1.00 |

**C: Retail** (3,476 Unique Properties; 10,872 Observations)

| | Mean | SD | Min | Median | Max |
|---|---|---|---|---|---|
| Lease Term (years) | 5.98 | 3.38 | 1.00 | 5.00 | 26.00 |
| Effective Rent ($/sqft/year) | 32.99 | 17.90 | 5.85 | 28.96 | 147.42 |
| Lease Size (sqft) | 3,814.68 | 6,590.93 | 298.00 | 1,700.00 | 72,100.00 |
| Annual Escalation (%) | 1.29 | 1.44 | 0.00 | 0.00 | 7.17 |
| Free Rent (months) | 0.91 | 1.75 | 0.00 | 0.00 | 18.00 |
| TI Allowance ($/sqft) | 5.49 | 15.18 | 0.00 | 0.00 | 214.00 |
| Concession Ratio (%) | 1.61 | 2.75 | 0.00 | 0.00 | 15.64 |
| Lease: NNN (1/0) | 0.82 | 0.38 | 0.00 | 1.00 | 1.00 |
| Renovation-adjusted Age (years) | 27.12 | 22.64 | 0.00 | 24.00 | 120.00 |
| Building Class: A (1/0) | 0.06 | 0.24 | 0.00 | 0.00 | 1.00 |

*Note:* This table reports summary statistics. Initial rent and TI allowance are expressed as unit rent per square foot. Annual growth refers to the constant yearly rate at which initial rent would need to increase to reach the final rent by the end of the lease term. It is calculated as the compound annual growth rate.

gross and modified gross leases. Gross rents are higher than NNN rents because under gross leases, the lessor is responsible for operating expenses such as property taxes, insurance, and maintenance. The prevalence of lease structures varies substantially by property type: NNN leases account for 13% of office leases but are the dominant structure for industrial (64%) and retail (86%) properties. Subleases are uncommon across all property types. The majority of lease contracts are new leases rather than renewals or extensions. We observe tenant-industry classifications for approximately 80% of the sample, covering 27 categories. The distribution of tenant industries is provided in the complete tables in Appendix C.

Table 2 reports summary statistics for office properties by market, ordered by the population of the corresponding metropolitan statistical area (MSA) based on 2024 Census population estimates. Relative to MSA population rankings, the CompStak data overrepresent the SF Bay Area, Los Angeles, Washington DC, and Atlanta, likely reflecting both market activity levels and CompStak's data-collection coverage.

Across office markets, the average lease term is approximately five years, with New York City exhibiting a notably longer average term. Lease concessions are widely used across all U.S. office markets. Given the localized nature of real estate markets, we analyze each major U.S. market separately in our empirical analysis.

# 3 Model

## 3.1 Instantaneous Spot Rents

We begin by decomposing the effective rent for a long-term lease into its fundamental components. The effective rent is defined as the constant rent that yields the same present value as the actual lease with all its contractual features: free rent periods, tenant improvements, escalation clauses, and other provisions. Specifically, the present value $V_{it}$ of a lease $i$ in property $j$ commencing at time $t$ for lease term $\tau_{it} \equiv T_{it} - t$ with contractual rent schedule

Table 2: **Summary Statistics by Market (continued on next page)**

**A: Office**

| Market | Lease Term (years) | Effective Rent ($/sqft/yr) | Lease Size (sqft) | Concession Ratio (%) | Unique Properties | N |
|---|---|---|---|---|---|---|
| New York City | 7.15 | 58.07 | 15,120 | 3.91 | 1,343 | 19,581 |
| | (3.93) | (29.03) | (25,209) | (3.98) | | |
| SF Bay Area | 4.05 | 41.01 | 7,148 | 2.38 | 4,052 | 46,718 |
| | (2.38) | (20.38) | (11,974) | (3.31) | | |
| Los Angeles | 4.76 | 33.34 | 8,329 | 4.09 | 3,940 | 41,636 |
| | (2.59) | (13.43) | (12,987) | (4.14) | | |
| Chicago | 5.00 | 23.31 | 8,579 | 4.13 | 943 | 6,210 |
| | (3.40) | (9.23) | (15,699) | (5.13) | | |
| Dallas Ft Worth | 4.66 | 21.10 | 8,396 | 3.18 | 812 | 4,963 |
| | (2.97) | (8.61) | (16,837) | (3.95) | | |
| Washington DC | 6.02 | 36.68 | 11,181 | 4.84 | 2,017 | 32,347 |
| | (3.26) | (11.97) | (19,378) | (4.95) | | |
| Phoenix | 4.32 | 22.58 | 6,845 | 3.00 | 816 | 5,430 |
| | (2.51) | (6.75) | (11,786) | (3.85) | | |
| Atlanta | 5.13 | 22.48 | 8,534 | 5.84 | 927 | 12,496 |
| | (2.67) | (6.81) | (13,090) | (5.04) | | |
| Boston | 5.85 | 40.92 | 17,421 | 2.86 | 986 | 6,745 |
| | (3.18) | (23.92) | (26,051) | (3.55) | | |
| Denver | 4.27 | 22.08 | 7,752 | 3.08 | 797 | 5,351 |
| | (2.92) | (7.78) | (12,897) | (4.02) | | |
| Houston | 4.38 | 22.23 | 5,818 | 1.71 | 741 | 6,393 |
| | (2.68) | (6.82) | (11,109) | (3.23) | | |
| San Diego | 4.46 | 30.94 | 6,639 | 3.73 | 891 | 6,155 |
| | (2.40) | (10.58) | (11,236) | (3.80) | | |

Table 2: **Summary Statistics by Market (continued)**

**B: Industrial**

| Market | Lease Term (years) | Effective Rent ($/sqft/yr) | Lease Size (sqft) | Concession Ratio (%) | Unique Properties | N |
|---|---|---|---|---|---|---|
| SF Bay Area | 4.02 | 15.29 | 19,375 | 1.75 | 4,666 | 19,913 |
| | (2.22) | (10.50) | (28,637) | (2.78) | | |
| Los Angeles | 4.04 | 11.05 | 43,322 | 1.88 | 7,241 | 24,348 |
| | (2.01) | (5.31) | (78,234) | (2.51) | | |
| Dallas Ft Worth | 5.03 | 5.91 | 54,488 | 2.80 | 1,296 | 4,539 |
| | (2.44) | (2.96) | (83,762) | (3.31) | | |
| Washington DC | 4.65 | 12.09 | 16,247 | 1.74 | 625 | 2,998 |
| | (2.61) | (4.64) | (20,646) | (2.77) | | |
| Atlanta | 4.98 | 6.07 | 68,515 | 2.65 | 1,169 | 4,633 |
| | (2.29) | (3.10) | (118,942) | (3.31) | | |
| San Diego | 3.96 | 14.86 | 14,274 | 2.50 | 1,275 | 5,096 |
| | (2.06) | (7.10) | (21,480) | (3.03) | | |
| Sacramento | 3.60 | 7.23 | 23,060 | 1.52 | 1,208 | 4,676 |
| | (2.19) | (3.24) | (54,813) | (2.58) | | |
| Las Vegas | 3.56 | 8.47 | 16,046 | 2.14 | 664 | 3,565 |
| | (1.82) | (3.58) | (31,074) | (2.89) | | |
| New Jersey | 5.43 | 10.50 | 92,593 | 0.79 | 695 | 2,143 |
| | (2.82) | (5.08) | (118,845) | (1.72) | | |

**C: Retail**

| Market | Lease Term (years) | Effective Rent ($/sqft/yr) | Lease Size (sqft) | Concession Ratio (%) | Unique Properties | N |
|---|---|---|---|---|---|---|
| SF Bay Area | 6.23 | 34.94 | 3,909 | 1.55 | 1,625 | 5,070 |
| | (3.28) | (17.37) | (6,467) | (2.65) | | |
| Los Angeles | 5.77 | 31.27 | 3,732 | 1.66 | 1,851 | 5,802 |
| | (3.44) | (18.18) | (6,697) | (2.84) | | |

*Note:* This table reports market-level summary statistics for office lease contracts. Each row presents the mean of each variable, with the corresponding standard deviation in parentheses directly below.

$R_{is}$ for $s \in [t, T_{it}]$ is expressed as:[3]

$$V_{it} = \int_{t}^{T_{it}} R_{is}\, e^{-\int_{t}^{s} r_u\, du}\, ds, \tag{2}$$

where $r_u$ denotes the instantaneous risk-free interest rate. Assuming that the risk-free interest rate $\bar{r}_t$ is constant over the lease term, the effective rent $R^e_{it}$ is defined as:

$$R^e_{it} \equiv V_{it} \left( \frac{1 - e^{-\bar{r}_t \tau_{it}}}{\bar{r}_t} \right)^{-1}. \tag{3}$$

We decompose the effective rent into two elements: the common effect of lease term $\tau$ and the remainder.

$$R^e_{it} = X_{it} \cdot f(\tau; t), \tag{4}$$

where $f(\tau; t)$ denotes a smooth, time-varying function of lease term, normalized at $f(0; t) = 1$ for all $t$. At this stage, we do not impose a strict no-arbitrage relationship across lease terms (e.g., Grenadier, 1995; Clapham and Gunnelin, 2003; Agarwal et al., 2011), but instead assume only a systematic relationship $f$ across lease terms that depends on market conditions.

The element $X_{it}$ represents the spot rent for each lease after removing lease term effects. The spot rent corresponds to the theoretical "zero-term" effective rent for immediate and instantaneous use: i.e., the y-intercept of the effective rent curve for each property. It characterizes the rent level at time $t$ for lease $i$ in property $j$, while the term structure function $f$ captures additional rent variation by lease term.

Following standard hedonic regression analysis, we further decompose the spot rent $X_{it}$ into three elements:

$$X_{it} = X_t \cdot X_j \cdot e^{\boldsymbol{Z}'_{it}\boldsymbol{\beta}}. \tag{5}$$

The first element $X_t$ denotes the Spot Rent Index (SRI), the stochastic process governing

[3]We do not theoretically model lease default but empirically control for default risk using tenant and property characteristics. We discuss how any omitted default risks can generate variation in the estimated growth expectations.

market-wide spot rent fluctuations for all leases. For example, the SRI may be relatively stable over time in Washington DC but more volatile in the San Francisco Bay Area. We do not yet specify a particular stochastic process for $X_t$. The second element $X_j$ is a property-specific rent shifter capturing the intrinsic, time-invariant characteristics of property $j$. For instance, prime locations (e.g., downtown) are associated with larger values of $X_j$. The third element $e^{\boldsymbol{Z}'_{it}\boldsymbol{\beta}}$ reflects the effect of a vector of property and contractual characteristics $\boldsymbol{Z_{it}}$ determined at contracting time $t$, such as building age, building class, lease type, tenant industry, and renewal status. For example, gross rents are typically higher than net rents because the landlord bears operating expenses. Long-run changes in neighborhood characteristics are captured by building class. These two cross-sectional elements, which correspond to non-stochastic hedonic variables, implicitly capture default risks that affect effective rents. Combining Equations (4) and (5) yields:

$$R^e_{it} = X_t \cdot X_j \cdot e^{\boldsymbol{Z}'_{it}\boldsymbol{\beta}} \cdot f(\tau; t). \tag{6}$$

We estimate the following panel regression for the logarithm of effective rent:

$$\ln R^e_{it} = a_t + a_j + \boldsymbol{Z}'_{\boldsymbol{it}}\boldsymbol{b} + \sum_{m=1}^{K} (c_m \, \tau^m_{it} + d_m \, \tau^m_{it} \, \bar{r}_t) + \varepsilon_{it}, \tag{7}$$

where time fixed effects $a_t$ capture the market-wide shift in log effective rent, representing the logarithm of the SRI $X_t$. Property fixed effects $a_j$ and the effects of a vector of contract and property characteristics $\boldsymbol{Z_{it}}$ (building age, building class, rent type, lease type, contractual rent-growth rate, and tenant industry specified at time $t$) shift the log effective rent. These shifters corespond to the logarithm of $X_j$ and $e^{\boldsymbol{Z}'_{it}\boldsymbol{\beta}}$, respectively. The log term structure is approximated by a $K$-th degree polynomial in lease term $\tau_{it}$, interacted with the prevailing interest rate $\bar{r}_t$ to capture the effect of discounting over the lease horizon. The disturbance $\varepsilon_{it}$ is an idiosyncratic error term.

We estimate Equation (7) with $K = 3$ using weighted least squares (WLS). Observations

are weighted so that each market's total weight is proportional to its GDP at the beginning of the sample period. Using the estimated coefficients, we construct lease-specific spot rents $\hat{X}_{it}$ by exponentiating $\hat{\alpha}_t + \hat{\alpha}_j + \boldsymbol{Z}'_{\boldsymbol{it}}\hat{\boldsymbol{b}}$ and applying a smearing factor $\phi = \frac{1}{n}\sum_{i=1}^{n} e^{\hat{\varepsilon}_{it}}$ to correct for Jensen's inequality (Duan, 1983):

$$\hat{X}_{it} = \phi e^{\hat{a}_t + \hat{a}_j + \boldsymbol{Z}'_{\boldsymbol{it}}\hat{\boldsymbol{b}}}. \tag{8}$$

Similarly, we estimate the market-level SRI $\hat{X}_t$ as:

$$\hat{X}_t = \phi e^{\hat{a}_t}. \tag{9}$$

Additionally, the estimated parameter for renovation-adjusted building age provides an estimate of the annualized depreciation rate $\delta$. Rounding to the nearest 0.1%, the estimated $\delta$ ranges from 0.1% for office properties to 0.2% for industrial and retail properties at the national level. Table A4 presents the estimation results.

## 3.2 Physical Growth Expectations

To estimate rent growth expectations, we parameterize the SRI as a geometric Brownian motion (GBM), following the literature on corporate and lease cash-flow modeling (e.g., Goldstein et al., 2001; Grenadier, 1995; Clapham and Gunnelin, 2003; Ambrose et al., 2002; Stanton and Wallace, 2009; Agarwal et al., 2011) and the more general modeling framework for illiquid assets (e.g., Ang et al., 2014):

$$dX_s = \mu^P X_s dt + \sigma X_s dW_s, \tag{10}$$

where $X_s$ denotes the SRI at time $s$, $\mu^P$ and $\sigma$ denote the drift and volatility under the physical probability measure $P$, respectively, and $W_s$ denotes a standard Brownian motion

under $P$.[4]

Given the estimated SRI for each market $\hat{X}_t$ (Equation (9)), we estimate constant parameters $\mu^P$ and $\sigma$ by fitting Equation (10) to the market SRI $\hat{X}_t$ over the entire sample period. The estimated $\hat{\mu}^P$ represents the unconditional growth expectations of the SRI.

## 3.3 Risk-Neutral Growth Expectations and Risk Premiums

We now introduce the no-arbitrage condition following Grenadier (1995) and Clapham and Gunnelin (2003). We assume that the present value of an actual long-term lease equals that of a strategy of rolling over instantaneous spot contracts. To express present values, we introduce the equivalent risk-neutral probability measure $Q$ defined by the Radon-Nikodym derivative $dQ/dP$. Under this risk-neutral measure, all asset returns equal the instantaneous risk-free rate of interest. The present value of the actual long-term lease $V_{it}$ defined by Equation (2) is expressed by using spot rents:

$$V_{it} = \underbrace{E_t^Q \int_t^{T_{it}} e^{-\int_t^s (r_u+\delta)\,du}\, X_{is}\, ds}_{\text{PV of Rolled-Over Spot Leases}}, \tag{11}$$

where $E_t^Q$ denotes the expectation operator under the risk-neutral probability measure $Q$. Note that the present value under risk-neutral pricing is equivalent to that based on risk-adjusted discounting under the physical probability measure $P$. $\delta$ denotes the rent depreciation rate. As a specific building physically ages and deteriorates over the lease term, its rental rate growth lags the growth of the constant-quality benchmark due to physical depreciation, functional obsolescence, and competitive disadvantage against newer properties (Bokhari and Geltner, 2018; Yoshida et al., 2024). Thus, the growth of rolled-over spot rents for a specific building must be adjusted downward by the rent depreciation rate $\delta$. Equivalently, the discount rate must be adjusted upward by adding the rent depreciation

[4]We employ a GBM parameterization for empirical tractability, although it is arguably more restrictive than the flexible state-space model approach by Aldana et al. (2025).

rate $\delta$.

As discussed in the asset pricing literature (e.g., Rubinstein, 1976; Merton, 1998; Lambrecht, 2017), the no-arbitrage pricing of lease assets should be understood based on consistent pricing across different lease terms, rather than on actual arbitrage trades, because the spot rent process is a non-traded theoretical construct. Jarrow (2023) formalizes this argument for real estate, real options, and other non-traded assets. Essentially, no-arbitrage pricing can be applied to an asset if it does not change the span of the market and its priced risk can be replicated by existing assets.

To analyze lease-specific growth expectations, we assume that the lease-specific spot rent also follows a GBM similar to Equation (10):

$$dX_{is} = \mu_i^P X_{is} dt + \sigma X_{is} dW_s. \tag{12}$$

The risk-neutral drift becomes:

$$\mu_i^Q = \mu_i^P - \lambda\sigma, \tag{13}$$

where $\lambda$ denotes the price of risk and $\lambda\sigma$ is the risk premium. By Girsanov's theorem, the process $W_s^Q \equiv \lambda t + W_s$ is a standard Brownian motion under $Q$. We can then rewrite the spot rent process as:

$$dX_{is} = \mu_i^Q X_{is} dt + \sigma X_{is} dW_s^Q. \tag{14}$$

We estimate $\mu_{it}^Q$ for each lease $i$ beginning at time $t$ by finding $\mu_{it}^Q$ to best satisfy Equation (11). Based on Equation (A.3) in Appendix A.1, the corresponding optimization problem is:

$$\hat{\mu}_{it}^Q \in \arg\min_{\mu^Q} \left( R_{it}^e \frac{1 - e^{-\bar{r}_t \tau_{it}}}{\bar{r}_t} - X_{it} \frac{1 - e^{-(\bar{r}_t + \delta - \mu^Q)\tau_{it}}}{\bar{r}_t + \delta - \mu^Q} \right)^2. \tag{15}$$

We numerically solve Equation (15) using a gradient-based solver. We exclude leases shorter than three years from our sample because the objective function is flat for short-

term leases, preventing reliable estimation (see Appendix A.2).

An advantage of our method is that the estimated lease-specific $\hat{\mu}_{it}^{Q}$ can be aggregated across any subsample. First, we construct a histogram of $\hat{\mu}_{it}^{Q}$ for each market over the entire sample period and compute unconditional risk-neutral expectations via iterated expectations as $\hat{\mu}^{Q} = E[\hat{\mu}_{it}^{Q}]$. Second, we aggregate $\hat{\mu}_{it}^{Q}$ by quarter for each market to analyze conditional growth expectations. Third, we aggregate $\hat{\mu}_{it}^{Q}$ by lease term to analyze the term structure of rent growth expectations.

Finally, we estimate the unconditional risk premium and the price of risk for each market by taking the difference between $\hat{\mu}^{P}$ and $\hat{\mu}^{Q}$, based on Equation (13).

### 3.4 Summary of Estimation Procedure

Figure 1 summarizes our estimation procedure. Using long-term lease data, we first estimate lease-specific spot rents $\hat{X}_{it}$ and construct national and market-level Spot Rent Indexes (SRIs) $\hat{X}_{t}$ by using the term structure of lease rates. From the estimated SRIs, we estimate unconditional rent growth expectations under the physical probability measure $\hat{\mu}^{P}$ and volatility $\hat{\sigma}$ by fitting a geometric Brownian motion. Separately, assuming no arbitrage between the observed lease present value and the present value of estimated lease-specific spot rent $\hat{X}_{it}$, we estimate implied risk-neutral growth expectations $\hat{\mu}_{it}^{Q}$ in the geometric Brownian motion for each lease. We then aggregate these lease-level estimates to obtain unconditional risk-neutral expectations $\hat{\mu}^{Q}$ and estimate the unconditional risk premium $\lambda\hat{\sigma}$ as $\hat{\mu}^{P} - \hat{\mu}^{Q}$. Finally, assuming a constant risk premium, we recover conditional physical growth expectations $\hat{\mu}_{it}^{P} = \hat{\mu}_{it}^{Q} + \lambda\hat{\sigma}$ to study their dynamics and term structure.

## 4 National Results

This section presents national-level estimates of the SRI, growth expectations, and risk premiums for office, industrial, and retail properties. We begin by estimating ex-post SRIs

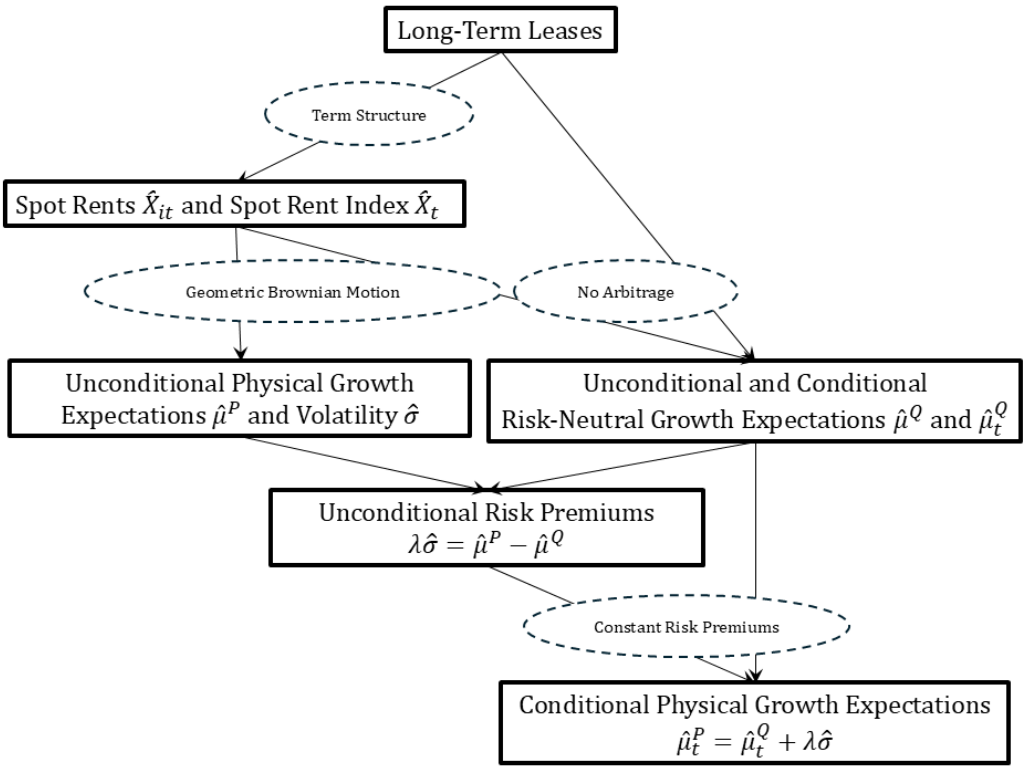



Figure 1: Overview of Estimation Procedure

using the empirical framework described in Section 3 and contrast them with the Producer Price Index (PPI) for office rents and the MSCI Office Commercial Property Price Index (CPPI). Next, using the estimated national SRI for each property type, we estimate unconditional rent growth expectations and volatility under the physical probability measure $P$. Separately, we estimate ex-ante, forward-looking growth expectations under the risk-neutral probability measure $Q$ for each long-term lease using Equation (15). By aggregating these lease-level expectations to the national level over the entire sample period, we infer the unconditional risk premium as the difference in rent growth between the two probability measures ($P$ and $Q$). Finally, we aggregate risk-neutral expectations quarterly to derive conditional expectations and by lease term to derive the term structure of rent growth expectations.

Figure 2 summarizes our estimation results by combining the realized SRI with five-year conditional rent growth expectations adjusted for risk premiums. This "porcupine" chart provides insights into the relationship between ex-ante growth expectations and ex-post

realizations (e.g., Crump et al., 2016; Castle et al., 2021). The detail of the realized SRI, expectations, and risk premiums are discussed in later sections.

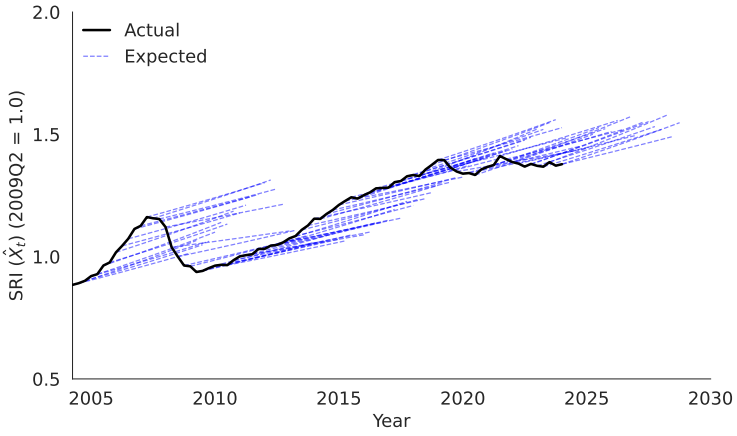
The figure reveals that growth expectations embedded in long-term leases are considerably more stable than realized SRI growth. Specifically, expectation paths tend to be flatter than the actual SRI trajectory during appreciation phases and steeper during depreciation phases, possibly suggesting that actual rent dynamics are largely driven by unexpected market shocks. However, striking pattern emerges during the post-GFC recovery period: even after years of sustained growth, expectations persistently underestimated actual rent growth. This systematic underestimation is also consistent with studies documenting systematic forecast errors arising from oversmoothing and rigidity in forecast revisions (e.g., Coibion and Gorodnichenko, 2012, 2015; Koch and Noureldin, 2024).

Despite their relative stability, growth expectations evolve gradually in response to market conditions. For office properties, expectations were nearly flat in 2004 but increased modestly approaching the pre-GFC peak. Following the GFC, expectations rose steadily throughout the 2010s as the realized SRI exhibited sustained growth. In the 2020s, as office rents stagnated, growth expectations flattened once again. This temporal pattern suggests that expectations respond to actual rent changes with considerable lags—that is, expectations in the commercial leasing market are backward-looking and adaptive rather than forward-looking.

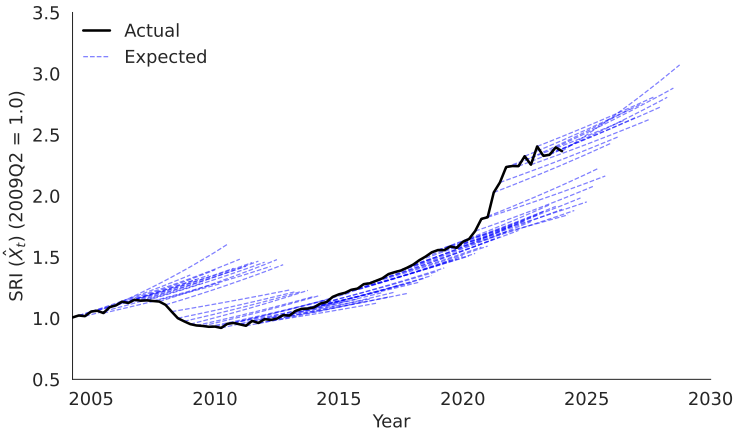
The significant variations observed in retail expectations likely reflect the more limited geographic coverage in our retail sample. When substantial heterogeneity exists across markets, a sample concentrated in fewer geographic areas tends to exhibit greater temporal volatility in aggregate expectations, as idiosyncratic market shocks are not diversified away. We examine this cross-market heterogeneity in detail in Section 5.

Figure 2: **Realized National SRIs and Growth Expectations**

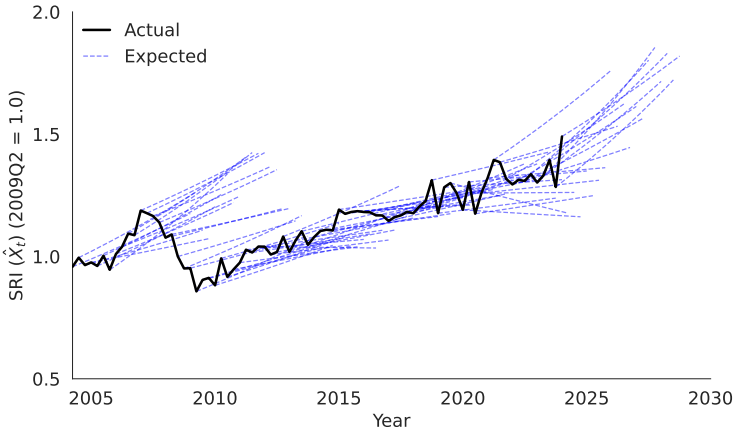
(a) Office




(b) Industrial




(c) Retail




*Note:* This figure combines the realized SRI with five-year expected rent paths based on growth expectations estimated at each quarter.

## 4.1 Spot Rent Indexes

Figure 3 contrasts the estimated national SRIs with the PPI for commercial real estate rents and MSCI Real Assets' Office CPPI (Commercial Property Price Index). The blue solid lines with square markers show the point estimates of the national SRIs, with the shaded band representing ±2 standard error confidence intervals. The dashed lines represent the PPI rent index (available from 2009Q2), while the dash-dotted lines represent the MSCI CPPI. All series are normalized to 1.00 in 2009Q2.

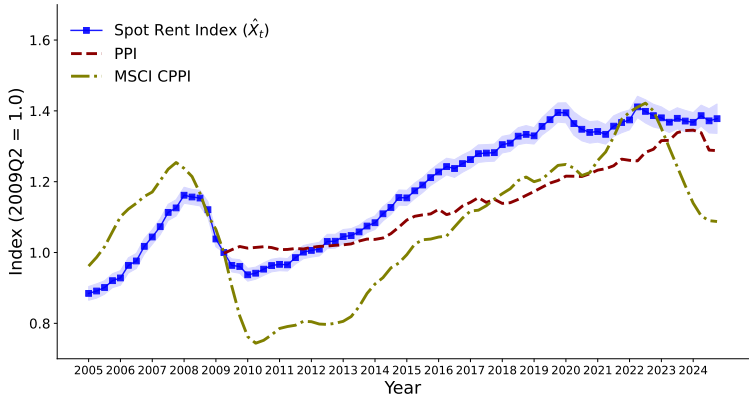
Panel (a) for offices shows that the SRI is substantially more volatile than the PPI and aligns more closely with known macroeconomic cycles. The fundamental difference between the two series lies in their behavior during and after the GFC and the post-pandemic period. The PPI does not show a significant decline in office rents in 2009 and 2010, while the SRI shows a significant correction in rents through 2010Q2. During the post-GFC recovery, the PPI increased only moderately, whereas the SRI exhibits faster growth throughout the 2010s. Following the COVID-19 pandemic, the PPI showed no rent correction through 2024, whereas the SRI has stagnated since 2020 when remote work increased significantly.

The MSCI office CPPI exhibits even greater volatility than the SRI because it is a repeat-sale price index that captures the present discounted value of future cash flows, whereas the SRI captures contemporaneous rent for spot leases. Consequently, the CPPI declined more dramatically during the GFC, reflecting elevated risk premiums, downward revisions to long-term cash flow expectations, and reduced market liquidity. During the post-GFC period, the CPPI increased more rapidly than the SRI, reflecting the reversal of these factors. Interestingly, the SRI shows rent corrections earlier than the CPPI shows price corrections in the post-pandemic period. The CPPI continued rising through 2021 and 2022 even as the SRI already exhibited stagnant lease rates.

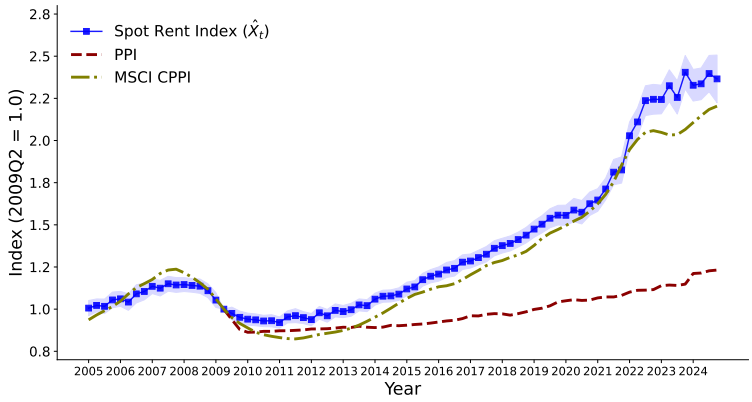
Panel (b) reveals a dramatic divergence between the SRI and the PPI for industrial properties. Following a similar decline in 2009, the SRI increased at a significantly higher rate than the PPI throughout the 2010s, creating a widening gap. Moreover, the SRI accelerated

Figure 3: **U.S. SRI and Other Indexes**

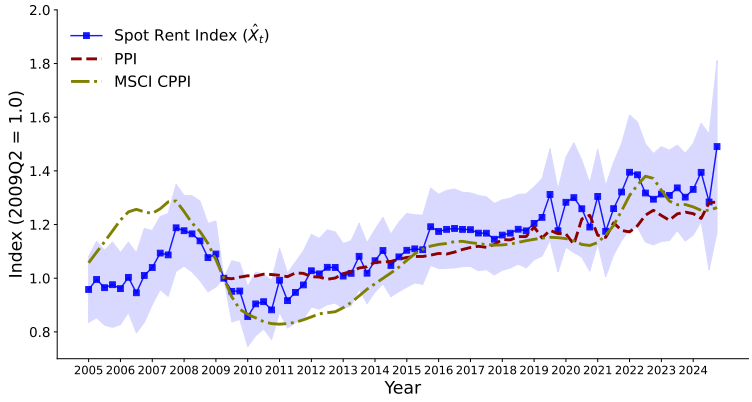
(a) Office




(b) Industrial




(c) Retail




*Note:* This figure contrasts the national Spot Rent Index (SRI) for office (a), industrial (b), and retail (c) properties with the PPI for real estate rents and the MSCI Office Commercial Property Price Index (CPPI). The shaded band represents ±2 standard error confidence intervals around the SRI. All series are normalized to 1.00 in 2009Q2.

even further in the post-pandemic period. This SRI growth is consistent with reports that e-commerce and data centers drove strong demand for industrial space. In contrast, the PPI shows no such acceleration in recent years.

The SRI is largely consistent with the CPPI, except that the SRI exhibited a sharper increase in 2021 and 2022. This consistency between rent and price indexes partly reflects the fact that industrial properties have limited conversion options to alternative uses, reducing embedded option value in prices. It also suggests that industrial properties have relatively stable cash growth expectations, risk premiums, and market liquidity.

Panel (c) shows much closer alignment among the SRI, PPI, and CPPI for retail properties. All three indexes track well-known macroeconomic cycles similarly. Due to the limited sample size, the SRI has significantly larger standard errors, and both the PPI and CPPI fall within the two-standard-error confidence band. This consistency suggests that retail properties have limited conversion options and relatively stable rent growth expectations.

## 4.2 PPI and SRI

The SRIs capture macroeconomic cycles, including the GFC and pandemic. Notably, we find a substantial and persistent divergence between the SRIs and the PPI, raising concerns about the PPI's effectiveness as a measure of commercial rent inflation. To aid interpretation, we review the construction of these indexes and their differences.

Table 3 contrasts PPI and SRI. The results have several important implications for interpreting the PPI. Most notably, the PPI may understate the magnitude of shocks to commercial rent levels. For instance, the PPI does not capture the declines in office rents during the GFC and after the pandemic. Unlike the PPI, the SRI captures market dynamics that the PPI overlooks.

According to U.S. Bureau of Labor Statistics (2011), the PPI measures the actual transaction prices received by producers, which differs from our spot rent concept. Although the handbook does not reveal the details of commercial rent measurement, the PPI aggregates

Table 3: **Comparison of PPI and SRI**

| | **PPI (BLS)** | **SRI** |
|---|---|---|
| Price concept | Average contract rents for producers | Instantaneous spot rent implied by new leases |
| Data Source | BLS survey | CompStak lease data |
| Lease rates | Gross rents only | Rents adjusted for gross or net leases, concessions, and characteristics |
| Geography | National | National and local markets |
| Geographic Weight | Not published | GDP weights |
| Property Types | Office, industrial, retail, residential | Office, industrial, retail |

*Notes*: PPI denotes the Producer Price Index published by the BLS. The SRI denotes the spot rent index estimated in this study.

prices for all in-place leases with various contract terms. Critically, because commercial leases are typically long-term contracts, many in-place leases were contracted years before the observation month.

Additionally, lease structures vary widely: some maintain constant flat rents throughout the term, while others feature graduated rents with scheduled step-ups. Compounding this issue, the PPI does not account for lease concessions, such as free rent and TI allowances, which are widely used to respond to rapidly changing market conditions. Because the PPI focuses on gross contract rents rather than effective rents, it misses fluctuations in concession-adjusted effective rents. These limitations suggest that quality adjustment in the PPI is insufficient for capturing true rental market dynamics.

In contrast, the SRI isolates spot rents by modeling and stripping out lease-term effects. It also controls for other lease and property characteristics to estimate a quality-adjusted rent index. Most importantly, the SRI reflects the instantaneous service price based on new contracts for each month, providing timely information about market conditions. Thus, we view the SRI as a better measure of the price level in commercial real estate markets, given its well-defined scope and explicit controls.

The SRI shares similar characteristics with marginal rent indexes for housing (e.g., Ambrose et al., 2015, 2023; Joshua Clark, 2022; Adams et al., 2024). These housing marginal rent indexes capture the dynamics of newly contracted one-year residential rents, making them more volatile and more highly correlated with contemporaneous macroeconomic conditions than the rent component of the Consumer Price Index (CPI), which largely reflects stable renewal rents.

We also clarify the interpretation of the SRIs. Because commercial real estate markets are highly heterogeneous, the national SRI reflects the weighting scheme used in estimation. Specifically, we estimate Equation (7) using weighted least squares (WLS), where observations are weighted so that each market's total weight is proportional to its GDP at the beginning of the sample period. Because the BLS does not publish geographic weights for the PPI, comparisons between the PPI and our SRI at the national level should be interpreted with caution. Nevertheless, the SRI appears to track macroeconomic cycles more closely at the aggregate level.

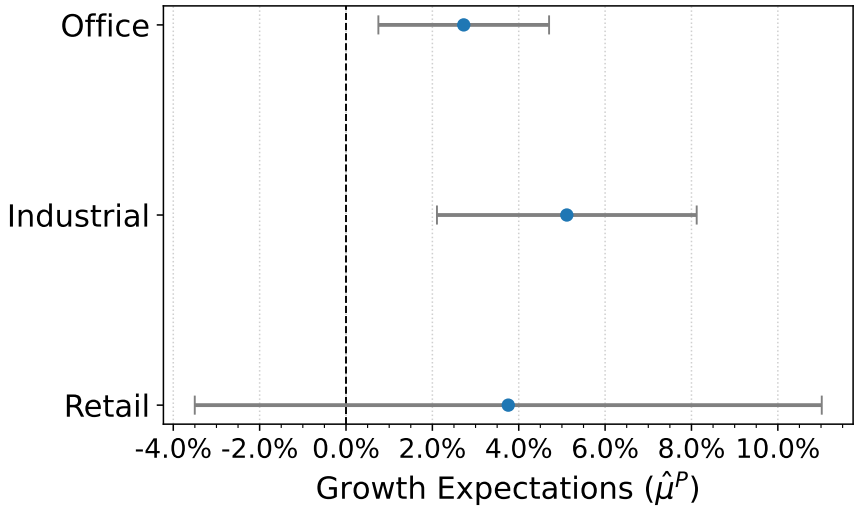
## 4.3 Growth Expectations

Using the SRI, we estimate rent growth expectations. As we discuss in Section 3, we estimate two types of expectations that differ in both estimation methods and interpretation. The first is objective, unconditional rent growth expectations under the physical probability measure $P$, represented by the drift parameter $\mu^P$ of a GBM (Equation (12)) fitted to the estimated quarterly SRIs between 2005 and 2024 (Figure 3). The second is ex-ante, forward-looking growth expectations under the risk-neutral probability measure $Q$, derived from Equation (15) for each long-term lease. The estimation uses lease-specific spot rents from Equation (8). Risk-neutral expectations are generally lower than physical expectations, with the difference implicitly reflecting market participants' required compensation for bearing spot rent risk.

Figure 4 displays unconditional rent growth expectations under the physical measure $P$

with 95% confidence intervals. Because the approximately 20-year sample provides a limited number of quarterly observations, inference on unconditional rent growth expectations is noisy, resulting in relatively wide confidence intervals (Merton, 1980). However, we follow the literature and use these estimates as our best available measures. The estimated unconditional rent growth expectations for office and retail properties are approximately 2.5%, while expectations for industrial properties are 4.5%. Overall, these estimates are consistent with economic intuition in terms of their magnitude.

Figure 4: **Unconditional Rent Growth Expectations**

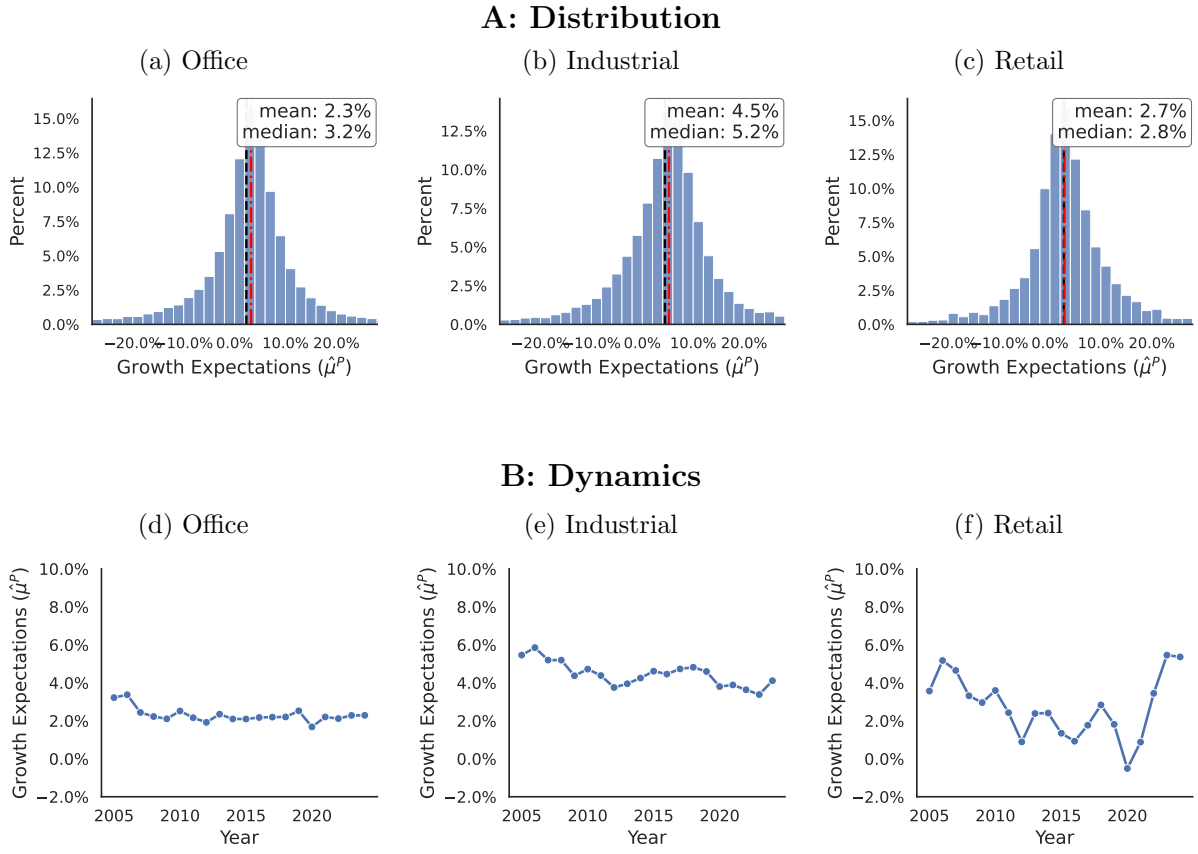



*Note:* This figure plots the estimated rent-growth expectations under the physical probability measure $P$, obtained by fitting Equation (12) to the estimated quarterly U.S. SRI from 2005 to 2024 shown in Figure 3. Error bars denote 95% confidence intervals.

Figure 5 shows the distribution (Panel A) and dynamics of ex-ante rent growth expectations (Panel B). We first estimate the distribution under the risk-neutral measure $Q$ using individual lease-level data, and then convert it to the physical measure $P$ by adding the estimated market-specific risk premiums reported in Table 4. This conversion facilitates comparison with ex-post expectations implied by historical SRI dynamics. Panel A also shows both mean and median rent growth expectations by property type. Mean rent growth rates range from 2.3% for office properties, to 2.7% for retail properties, and up to 4.5% for industrial properties. These magnitudes are consistent with the estimated unconditional

rent growth expectations. Median growth rates are slightly higher than mean growth rates, reflecting left skewness in the underlying distributions.

Figure 5: **Distribution and Dynamics of Rent Growth Expectations**




*Note:* Panel A displays the distribution of estimated rent growth expectations converted to the physical measure $P$ by adding the unconditional market-specific risk premium, with the mean (black) and median (red) indicated. Panel B plots the time series of median conditional rent growth expectations, converted to the physical probability measure $P$ by adding the conditional market-specific risk premium.

Panel B plots the time series of national-level mean conditional rent growth expectations by year, constructed under the assumption of a constant risk premium. Rent growth expectations exhibit substantial time-series variation across all property types. Overall, expected rent growth displays an upward trend for office and industrial properties. However, while office growth expectations increased steadily until 2022, industrial and retail expectations exhibit larger short-term volatility during the GFC and pandemic periods.

Importantly, recently contracted leases provide forward-looking rent expectations, as typical lease terms exceed five years. In the office market, expected rent growth declined by more than one percentage point following the COVID-19 shock. Although the office SRI did not exhibit a sharp decline through 2024 (Figure 3), recently signed leases appear to have incorporated anticipated future rent declines. In contrast, for industrial and retail properties, significant downward adjustments are observed only during the pandemic period.

## 4.4 Risk Premiums

The difference between physical and risk-neutral rent growth expectations represents the risk premium in Equation (13). We estimate the market-level unconditional risk premium as $\hat{\mu}^P$ minus the market mean of lease-level risk-neutral expectations $\left(\hat{\mu}^Q\right)$. This risk premium is equivalent to the return risk premium (see Appendix A.3). We also estimate the price of risk by dividing the risk premium by the estimated volatility.

Table 4 reports national estimates by property type for the risk premium, market price of risk, rent growth expectations under the physical probability measure $P$ and the risk-neutral probability measure $Q$, and volatility. The reported risk-neutral rent growth corresponds to the mean of the lease-level estimates shown in Figure 5. The results are based on long-term leases with maturities exceeding ten years, while the results for the full sample is in Appendix C. Because unconditional expectations under the physical probability measure $(\hat{\mu}^P)$ are estimated from approximately twenty years of data, unconditional risk-neutral expectations $(\hat{\mu}^Q)$ are also computed from the long-term subsample to ensure comparability. Estimated unconditional risk premiums are 1.6% for office, 4.7% for industrial, and $-3.3\%$ for retail properties. The estimate for retail properties may be less reliable than those for other property types due to the smaller sample size and greater heterogeneity within the retail sector.

To interpret these differences, we decompose the risk premium into the market price of risk and volatility. As Equation (13) shows, the risk premium equals $\lambda\sigma$, where a higher market

Table 4: **Unconditional Risk Premium and the Price of Risk**

| Market | Risk Premium | Price of Risk | $\hat{\mu}^P$ | $\hat{\mu}^Q$ | $\hat{\sigma}$ |
|---|---|---|---|---|---|
| Office | 0.016 | 0.440 | 0.023 | 0.008 | 0.035 |
| Industrial | 0.047 | 0.921 | 0.045 | -0.002 | 0.051 |
| Retail | -0.033 | -0.331 | 0.027 | 0.060 | 0.099 |

*Note:* This table reports unconditional risk premiums, prices of risk, and estimates of the SRI drift and volatility. The physical drift, $\hat{\mu}^P$, and volatility, $\hat{\sigma}$, are point estimates from the model fit. The risk-neutral drift, $\hat{\mu}^Q$, is the mean estimated drifts implied by Equation (15).

price of risk ($\lambda$) implies greater compensation per unit of uncertainty ($\sigma$). Comparing across property types, rent volatility is lowest for office properties (3.5%), moderate for industrial properties (5.1%), and highest for retail properties (9.9%).

However, these volatility and price of risk estimates must be interpreted with caution due to differences in sample size and the degree of geographic aggregation across property types. The retail sample, in particular, is limited to three markets, which may result in a greater volatility estimate.

To the best of our knowledge, we are the first to estimate market-level risk premium and prices of risk in the office lease market. These parameters are important inputs for calibration exercises in existing lease term-structure studies such as Clapham and Gunnelin (2003) and Agarwal et al. (2011), as well as for other simulation analyses. Nevertheless, we acknowledge that our estimates may be unstable due to substantial uncertainty in the inference of rent-growth parameters under the physical probability measure.

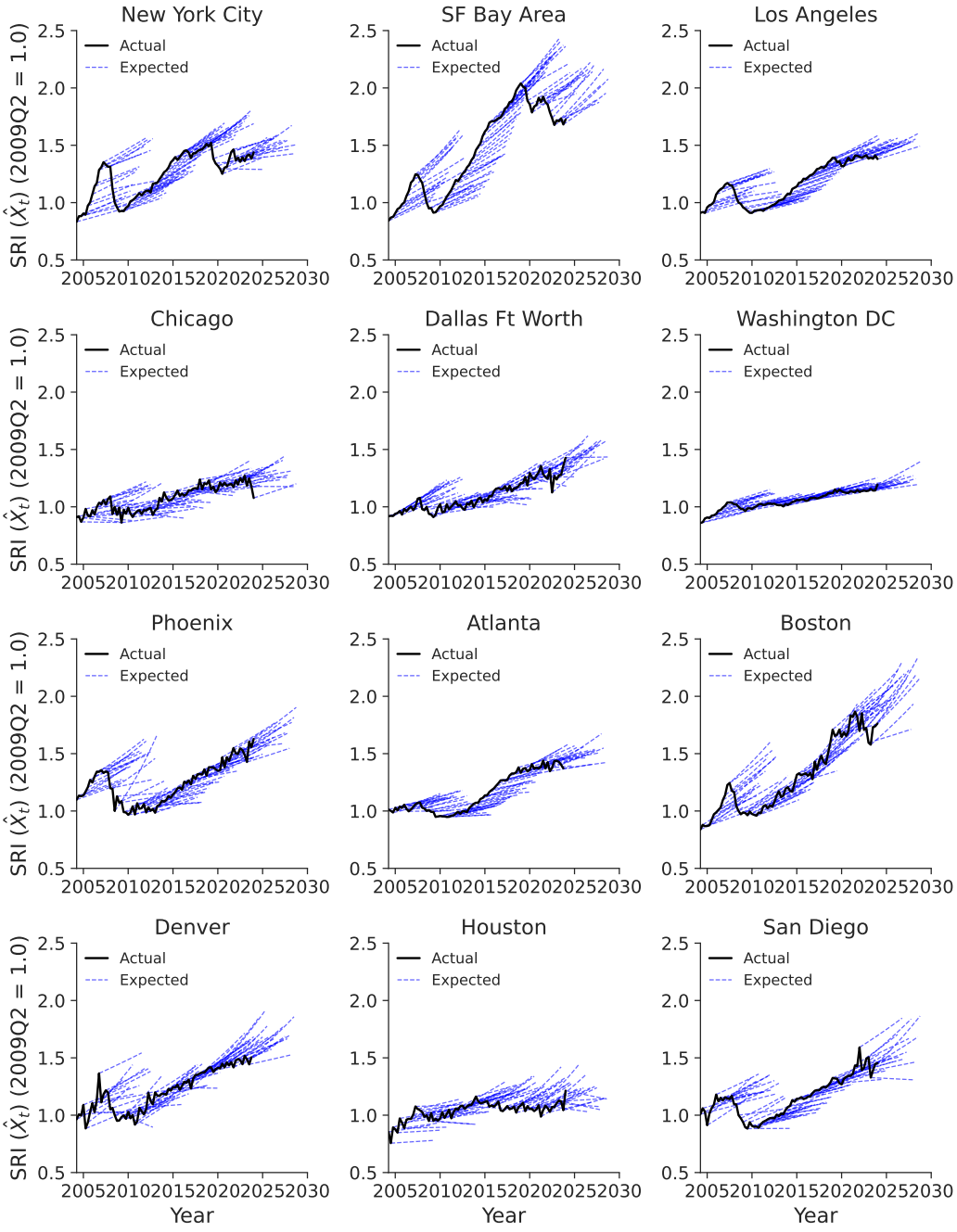
# 5 Major US Markets

Focusing on major U.S. markets, we estimate SRIs, growth expectations, and risk premiums for twelve office markets, nine industrial markets, and two retail markets. Figure 6 summarizes the results by combining the SRI, growth expectations, and risk premiums. We

discuss market-specific SRIs more extensively in Figure A4 in the Appendix.

Figure 6: **Realized SRIs and Growth Expectations (continued on next page)**

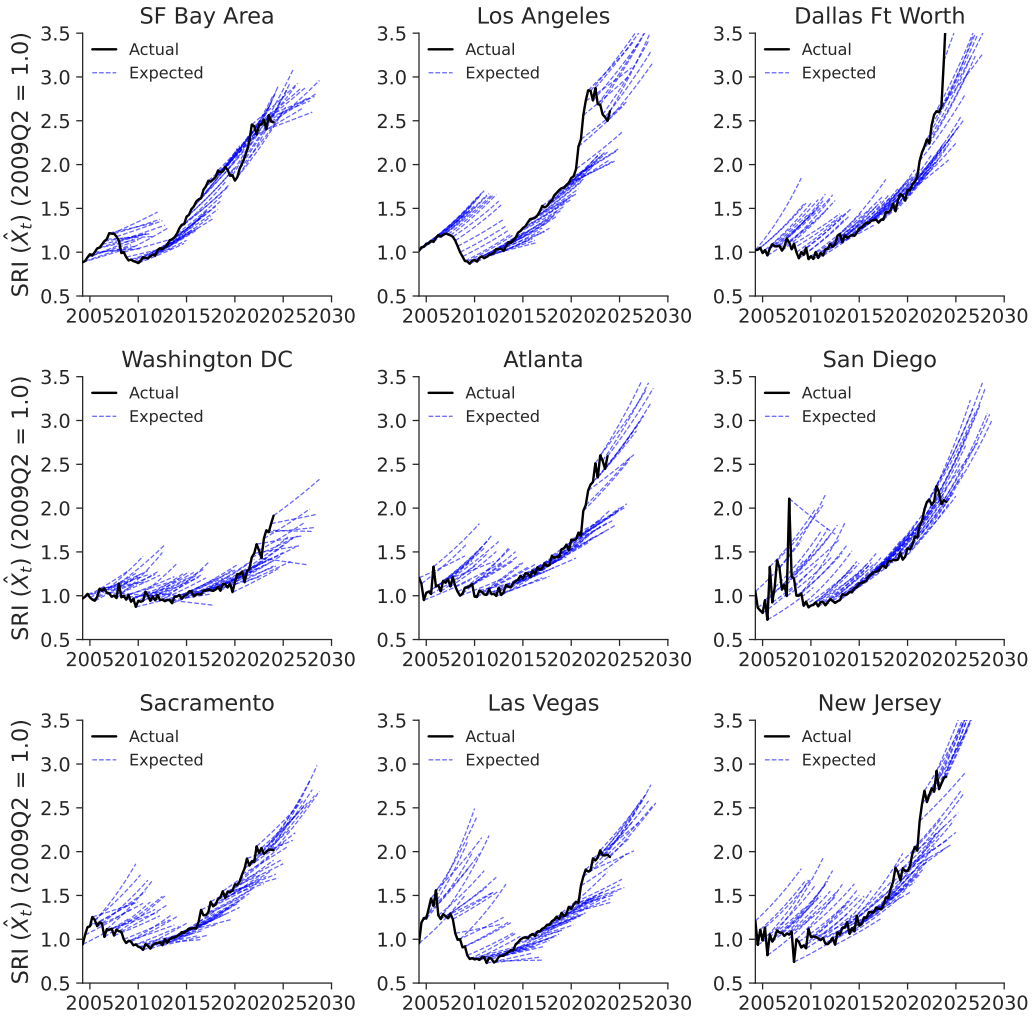
(a) Office



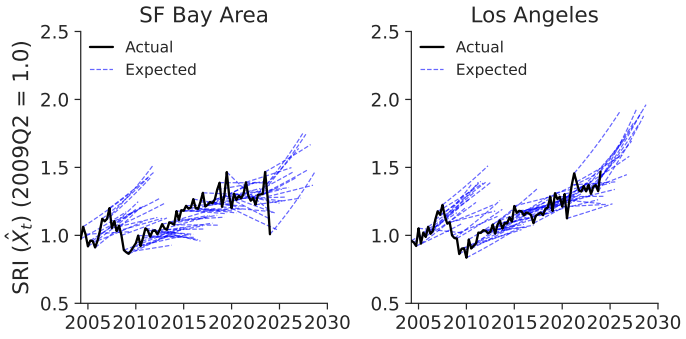

Consistent with the national results (Figure 2), growth expectations are relatively stable; that is, expectations tend to underestimate growth when the actual SRI is appreciating and

Figure 6: **Realized SRIs and Growth Expectations (continued)**

(b) Industrial




(c) Retail




*Note:* This figure combines the realized office SRIs (Figure A4) with five-year expected rent paths based on growth expectations estimated at each quarter.

overestimate growth when the SRI is declining. However, market-specific expectations vary over time more significantly than the national expectations. For instance, in the Chicago office market (Panel (a)), expectations were positive around 2006-2008 when the SRI increased, but turned negative between 2010 and 2013 following the sharp SRI decline during the GFC. Expectations then remained flat through 2019 despite continued SRI growth. Eventually, expectations turned positive between 2020 and 2022 precisely when the pandemic negatively impacted the office SRI, before turning negative again in 2024. This pattern suggests that expectations are formed in response to actual rent changes with considerable lags—that is, expectations in the commercial leasing market are backward-looking and adaptive. Similar dynamics are observed in other office markets in New York, the San Francisco Bay Area, Dallas-Fort Worth, and Boston.

Industrial properties (Panel (b)) exhibit more frequent alignment between expectations and realizations than office properties. In San Diego, the realized industrial SRI has tracked growth expectations closely since 2015. The San Francisco Bay Area shows similar alignment since 2020, while Dallas-Fort Worth and Washington DC exhibited consistency throughout the 2010s. Nevertheless, the sharp acceleration in industrial SRI during the 2020s exceeded growth expectations in Los Angeles, Dallas-Fort Worth, Washington DC, Atlanta, Las Vegas, and New Jersey. For retail properties (Panel (c)), the Los Angeles market exhibits alignment between expectations and realizations during the 2010s.

## 5.1 Growth Expectations

Using the SRI, we estimate rent growth expectations in major U.S. office markets. As we discuss in Section 3, we estimate two types of expectations that differ in both estimation methods and interpretation. The first is objective, unconditional rent growth expectations under the physical probability measure $P$, represented by the drift parameter $\mu^P$ of a GBM (Equation (12)) fitted to the estimated quarterly SRIs between 2005 and 2024 (Figure A4). The second is ex-ante, forward-looking growth expectations under the risk-neutral probabil-

ity measure $Q$, derived from Equation (15) for each long-term lease. The estimation uses lease-specific spot rents from Equation (8). Risk-neutral expectations are generally lower than physical expectations, with the difference implicitly reflecting market participants' required compensation for bearing spot rent risk.

Figure 7 displays unconditional rent growth expectations under the physical measure $P$ for each market with 95% confidence intervals. We observe heterogeneous growth rates across markets. Office growth rates range from approximately 1% in Chicago to approximately 4% in the San Francisco Bay Area and Boston. Similarly, Retail growth rates are 1% in the San Francisco Bay Area and approximately 3.5% in Los Angeles. Industrial growth rates are generally higher, ranging from approximately 4% in Washington DC to 8% in San Diego. We also estimate volatility, which is reported in Table 5 for the analysis of risk premiums.

For risk-neutral growth expectations, we aggregate the estimated lease-specific $\hat{\mu}_{it}^{Q}$ from Equation (15) at the market level. The distribution of $\hat{\mu}_{it}^{Q}$ for each market is summarized in Figure A6 in the Appendix, and the dynamics of the market-level conditional expectations is summarized in Figure A7 in the Appendix.

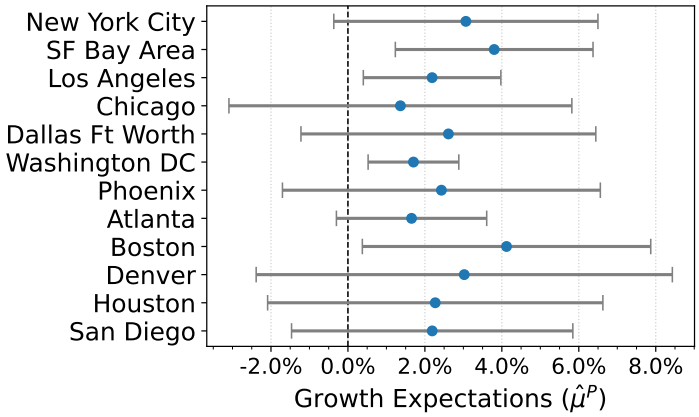
## 5.2 Risk Premiums

The difference between physical and risk-neutral rent growth expectations represents the risk premium (Equation (13)). We estimate the market-level unconditional risk premium as $\hat{\mu}^{P}$ minus the market mean of risk-neutral expectations for long-term leases $\left(\hat{\mu}^{Q}\right)$. This risk premium is equivalent to the return risk premium (see Appendix A.3). We also estimate the price of risk by dividing the risk premium by the estimated volatility. Section 6 discusses the distinction between unconditional and conditional risk premiums under alternative assumptions about risk premium constancy.

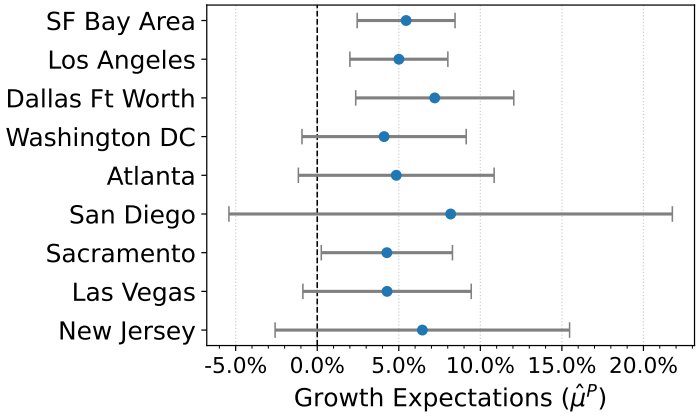
Table 5 reports unconditional risk premiums, prices of risk, long-term ($\geq$10 years) expectations under the physical measure $P$ $\left(\hat{\mu}^{P}\right)$ and risk-neutral measure $Q$ $\left(\hat{\mu}^{Q}\right)$, and volatility. For office properties (Panel (a)), risk premiums range from $-0.6\%$ in Wasington DC to 6.1%

Figure 7: **Unconditional Rent Growth Expectations**

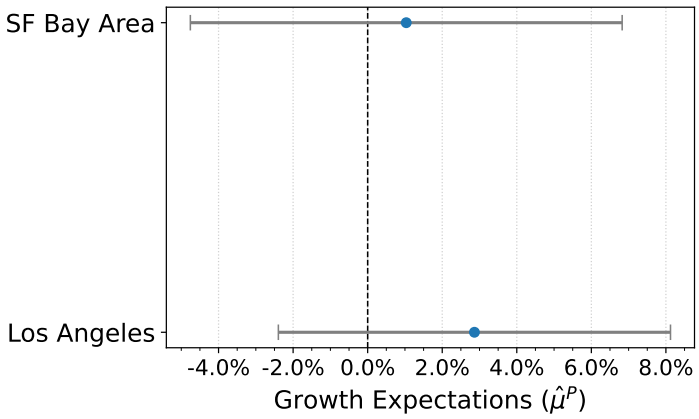
(a) Office




(b) Industrial




(c) Retail




*Note:* This figure plots the estimated rent-growth expectations under the physical probability measure $P$, obtained by fitting Equation (12) to the estimated quarterly market SRI from 2005 to 2024 shown in Figure A4. Error bars denote 95% confidence intervals.

in Denver. Overall, East Coast markets such as New York City and Washington DC exhibit lower risk premiums than south west markets such as Dallas-Fort Worth and Denver. Using Equation (13), we decompose the risk premium into the price of risk ($\lambda$) and volatility ($\sigma$). Comparing New York City and San Diego, both have similar, moderate volatility, so the gap primarily reflects the price of risk; San Francisco's $\lambda$ is 0.656 compared to Washington DC's $-0.231$. A plausible explanation is that Washington DC office market provides a hedge against macroeconomic downturns because of large public sector tenants. By contrast, San Francisco may have greater systematic risk due to the presence of growth industry.

For industrial properties (panel (b)), risk premiums range from $-1.0\%$ in Las Vegas to 9.1% in Dallas-Fort Worth. The San Francisco Bay Area exhibits the highest price of risk at 1.098, while Las Vegas shows the lowest at $-0.084$ as it is emerging as a national logistics hub. Retail risk premiums are significantly negative, possibly due to the noisy estimate of SRIs.

# 6 Discussion

## 6.1 Term Structure of Expectations

We aggregate the estimated expectations by lease term to examine the term structure of expectations across markets. This expectations term structure is related to, but distinct from, the conventional term structure of lease rates: it shows continuously compounded median annual growth rates through the lease term rather than differences in rent levels. Its shape is determined by the estimated risk-neutral drift $\hat{\mu}^{Q}$.

Figure 8 plots median rent growth expectations by lease term. For offices (panel (a)), expected growth rates are approximately zero at the short end of the term structure. That is, these short lease rates are set at the same level as the spot rent. For lease terms of 5 years or longer, lease rates embed long-term growth rates. For example, long-term growth rates are high for Denver, Phoenix, Dallas-Fort Worth, San Diego, and San Francisco Bay

Table 5: **Unconditional Risk Premium and Price of Risk**

(a) Office

| Market | Risk Premium | Price of Risk | $\hat{\mu}^P$ | $\hat{\mu}^Q$ | $\hat{\sigma}$ |
|---|---|---|---|---|---|
| New York City | 0.009 | 0.119 | 0.031 | 0.021 | 0.078 |
| SF Bay Area | 0.038 | 0.656 | 0.038 | -0.000 | 0.058 |
| Los Angeles | 0.012 | 0.297 | 0.022 | 0.010 | 0.041 |
| Chicago | 0.017 | 0.172 | 0.014 | -0.004 | 0.101 |
| Dallas Ft Worth | 0.055 | 0.631 | 0.026 | -0.029 | 0.087 |
| Washington DC | -0.006 | -0.231 | 0.017 | 0.023 | 0.027 |
| Phoenix | 0.039 | 0.417 | 0.024 | -0.015 | 0.094 |
| Atlanta | 0.008 | 0.180 | 0.017 | 0.009 | 0.044 |
| Boston | 0.036 | 0.418 | 0.041 | 0.006 | 0.085 |
| Denver | 0.061 | 0.505 | 0.030 | -0.031 | 0.122 |
| Houston | 0.015 | 0.147 | 0.023 | 0.008 | 0.099 |
| San Diego | 0.023 | 0.279 | 0.022 | -0.001 | 0.083 |

(b) Industrial

| Market | Risk Premium | Price of Risk | $\hat{\mu}^P$ | $\hat{\mu}^Q$ | $\hat{\sigma}$ |
|---|---|---|---|---|---|
| SF Bay Area | 0.075 | 1.098 | 0.054 | -0.020 | 0.068 |
| Los Angeles | 0.058 | 0.855 | 0.050 | -0.008 | 0.068 |
| Dallas Ft Worth | 0.091 | 0.825 | 0.072 | -0.019 | 0.110 |
| Washington DC | 0.064 | 0.562 | 0.041 | -0.023 | 0.114 |
| Atlanta | 0.050 | 0.368 | 0.048 | -0.001 | 0.135 |
| San Diego | 0.082 | 0.267 | 0.082 | 0.000 | 0.306 |
| Sacramento | 0.025 | 0.274 | 0.043 | 0.018 | 0.091 |
| Las Vegas | -0.010 | -0.084 | 0.043 | 0.053 | 0.117 |
| New Jersey | 0.046 | 0.223 | 0.064 | 0.019 | 0.205 |

(c) Retail

| Market | Risk Premium | Price of Risk | $\hat{\mu}^P$ | $\hat{\mu}^Q$ | $\hat{\sigma}$ |
|---|---|---|---|---|---|
| SF Bay Area | -0.051 | -0.386 | 0.010 | 0.061 | 0.131 |
| Los Angeles | -0.032 | -0.268 | 0.029 | 0.061 | 0.119 |

*Note:* This table reports, by market, risk premiums, prices of risk, and the estimated SRI drift and volatility. The physical drift, $\hat{\mu}^P$, and volatility, $\hat{\sigma}$, are point estimates from the model fit. The risk-neutral drift, $\hat{\mu}^Q$, is the within-market mean of the estimated drifts implied by Equation (15).

Area. As a result, these cities exhibit an upward-sloping term structure. In contrast, long-term expected growth is moderate in other cities, especially on the East Coast such as New York City, Washington DC, and Boston. The expectations term structure is relatively flat between 5 and 20 years for these cities.

For industrial properties (panel (b)), growth expectations on the short end is lower but positive. Long-term growth expectations are high in the San Francisco Bay Area, Dallas-Fort Worth,

## 6.2 Expectations Heterogeneity

To analyze heterogeneity in expectations, we aggregate physical growth expectations $\hat{\mu}_{it}^{P}$ across partitioned data along four dimensions: (1) lease size, comparing small, medium, and large spaces; (2) building age, comparing newer, medium-aged, and older structures; (3) property class (A, B, and C); and (4) lease type, contrasting gross, modified gross, and triple-net (NNN) leases. We focus on three office markets with large sample sizes: New York City, Washington DC, and the San Francisco Bay Area.

### 6.2.1 Lease Size

Figure 9 shows expectations for small ($< 5,000$ sq.ft.), medium ($5,000$-$20,000$ sq.ft.), and large ($\geq 20,000$ sq.ft.) leases. Long-term lease rates incorporate very different growth expectation dynamics by lease size.

First, larger leases on average have higher growth expectations than smaller leases in each market. In New York City, large leases consistently incorporate 4% annual growth, while smaller leases incorporate 3% growth before the pandemic. In the San Francisco Bay Area, growth rates are approximately 7% for larger leases in recent years but 1-4% for smaller leases.

Second, post-pandemic growth revisions are pronounced only for smaller leases. Smaller office leases in New York City show a particularly drastic decline in growth expectations to

Figure 8: **Rent Growth Expectations by Lease Terms (continued on next page)**

(a) Office

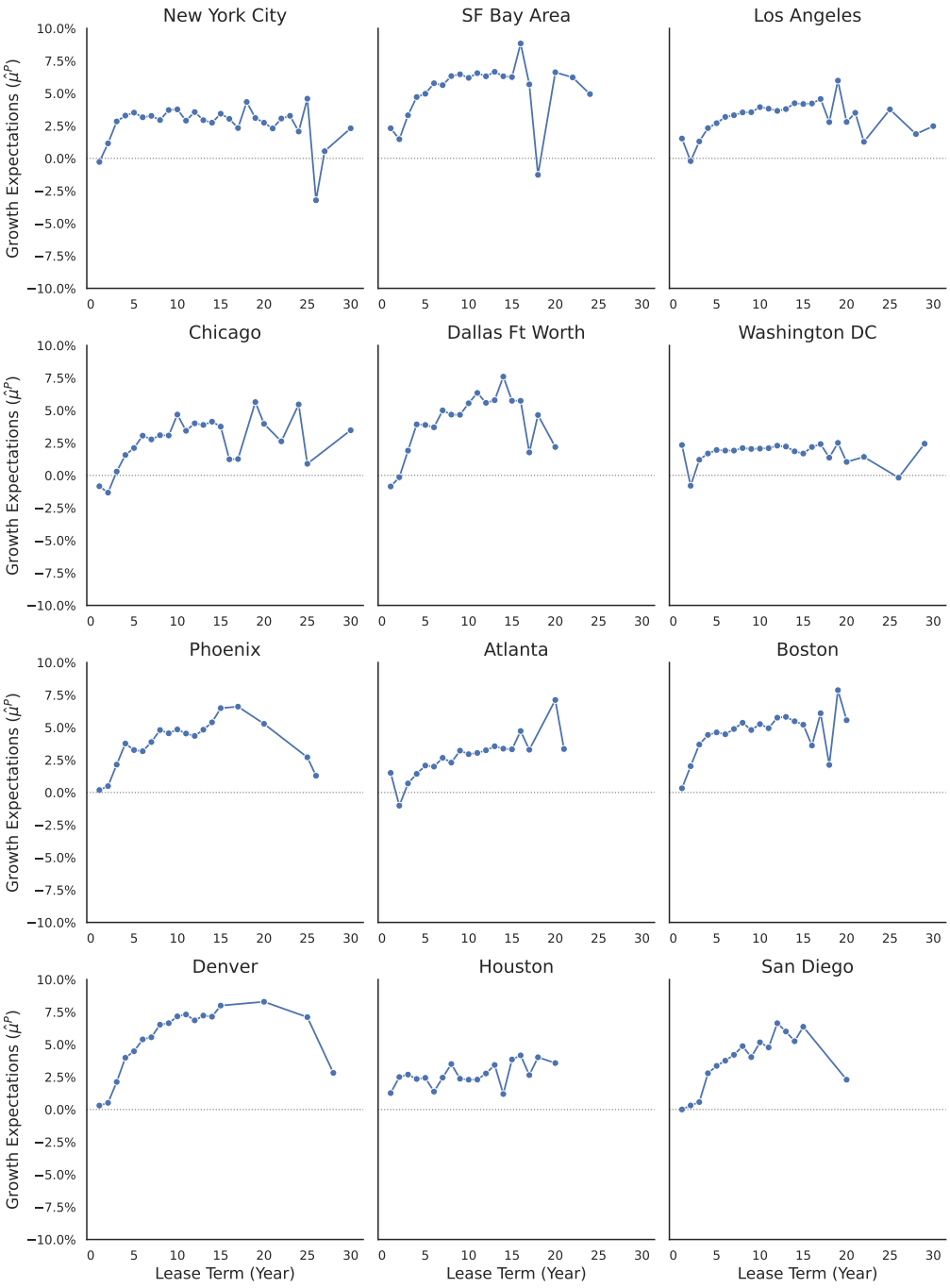
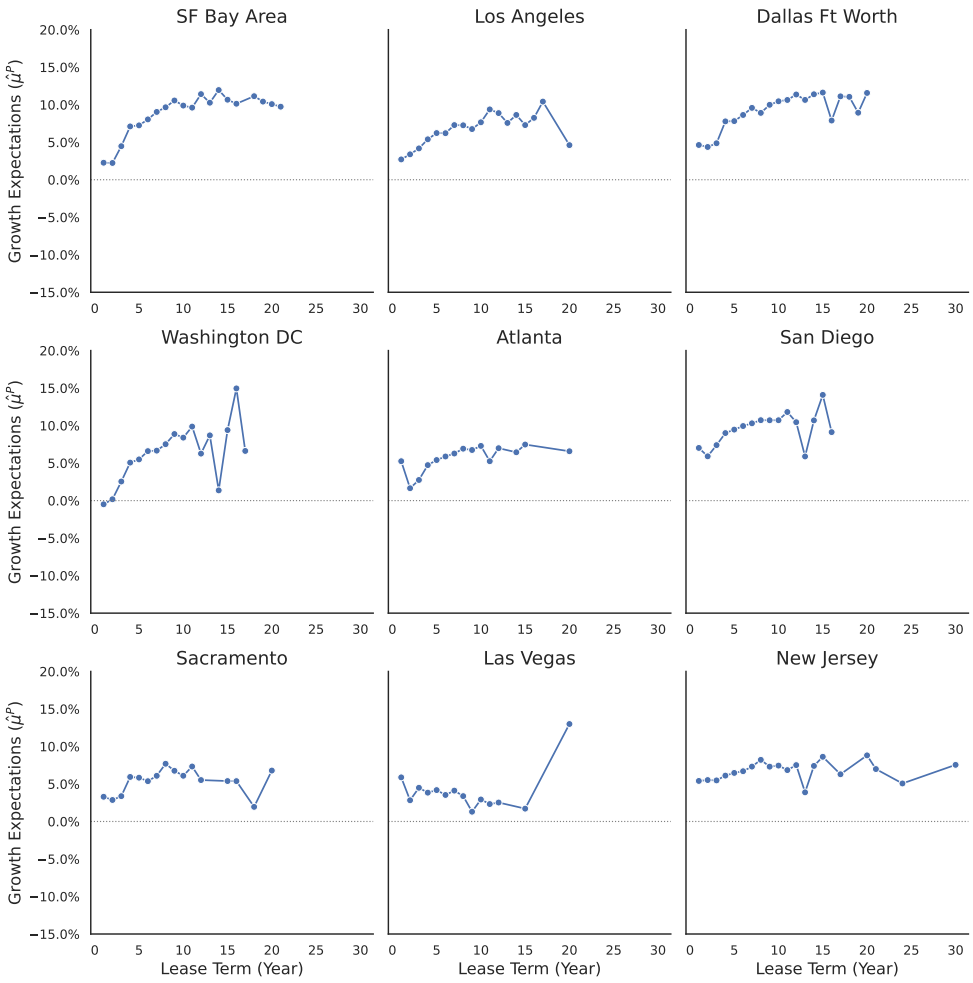
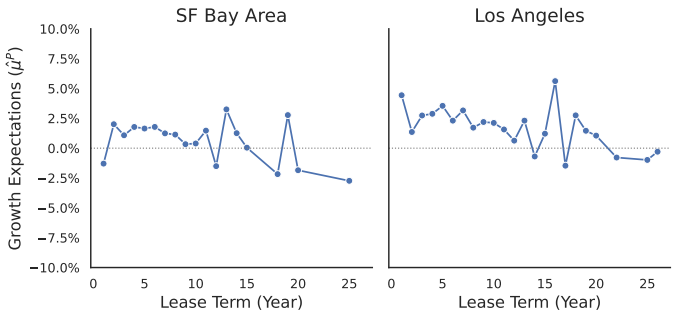


Figure 8: **Rent Growth Expectations by Lease Terms (continued)**

(b) Industrial




(c) Retail Property




*Note:* This figure plots the averages of the estimated rent-growth expectations under the physical probability $P$ by lease term in major U.S. markets.

a negative range without recovery. This finding is consistent with institutional investors' post-pandemic preferences for large floor plates with enhanced amenities.

Third, smaller office leases tend to have diminishing growth expectations, while larger leases maintain stable or even accelerating expectations. In the San Francisco Bay Area, expectations for smaller leases declined from 6% to 1% in 2021, while those for larger leases increased from 3% to 7%. A negative trend for smaller leases is observed in other markets as well.

### 6.2.2 Building Age

Figure 10 shows expectations for newer ($<$ 20 years), medium-aged (20-40 years), and older ($\geq$ 40 years) structures based on renovation-adjusted building age.

Newer properties tend to exhibit more stable expectations than older properties. Expectations for newer properties are consistently around 3% in New York City, 2% in Washington DC, and 5% in San Francisco. In contrast, older properties exhibit more significant variation, particularly an inverse U-shaped pattern: these older properties experienced growing demand during the economic expansion of the 2010s but are more vulnerable to reduced office demand in market downturns.

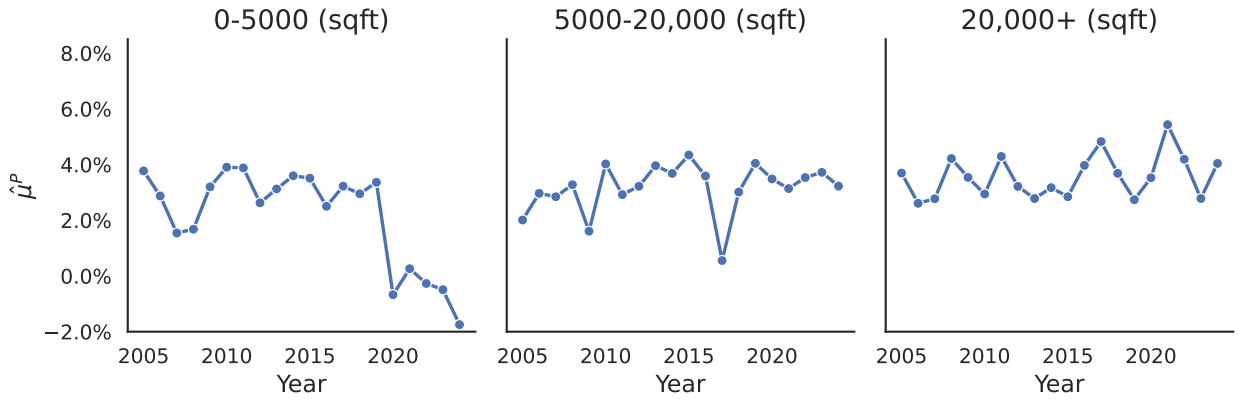
### 6.2.3 Class

Figure 11 shows expectations for Classes A, B, and C. These classifications are somewhat ad hoc and subjective but are commonly regarded by investors as an aggregate quality measure, particularly for office properties. Class A properties are usually larger, newer, and located in prime locations. Thus, this variable is correlated with lease size and building age. According to summary statistics (Tables A1, A2, and A3), Class A properties comprise 59% of the office sample but only 18% of the industrial sample and 5% of the retail sample. A majority of retail properties (73%) are unclassified.

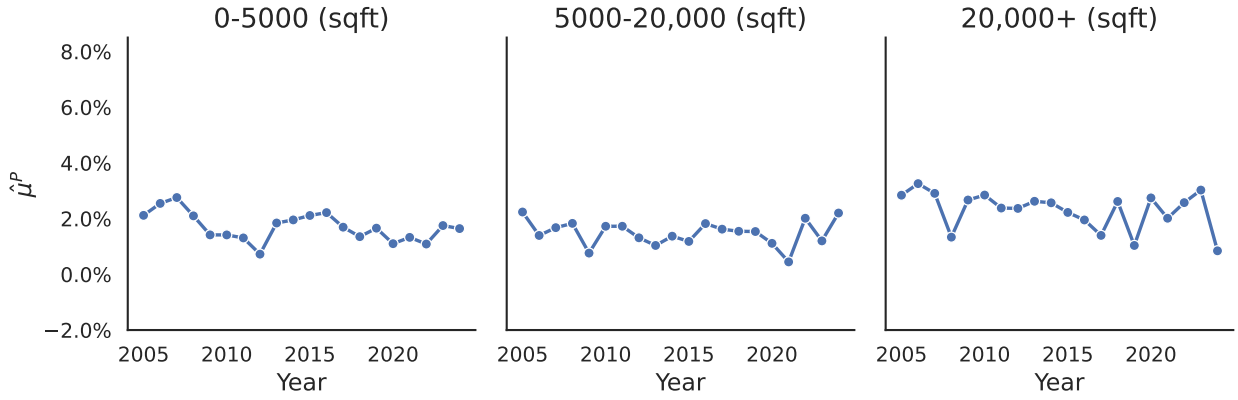
Class A properties tend to exhibit more stable and rigid expectations than lower classes.

Figure 9: **Office Growth Expectations by Lease Size**

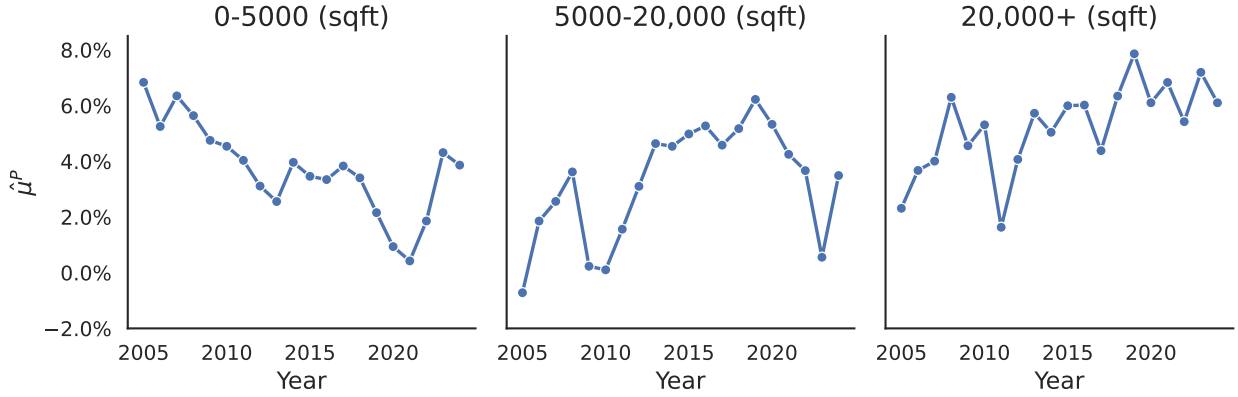
(a) New York City




(b) Washington DC




(c) San Francisco Bay Area




*Note:* This figure shows the average growth expectations $\hat{\mu}_t^P$ estimated annually for small ($< 5,000$ sq.ft.), medium ($5,000$-$20,000$ sq.ft.), and large ($\geq 20,000$ sq.ft.) leases in three office markets: (a) New York City, (b) Washington DC, and (c) San Francisco Bay Area.

Figure 10: **Office Growth Expectations by Building Age**




*Note:* This figure shows the average growth expectations $\hat{\mu}_t^P$ estimated annually for newer ($<$ 20 years), medium-aged (20-40 years), and older ($\geq$ 40 years) structures based on renovation-adjusted building age in three office markets: (a) New York City, (b) Washington DC, and (c) San Francisco Bay Area.

Growth expectations for Class A properties are consistently 4% in New York City, 2% in Washington DC, and 5% in the San Francisco Bay Area. Class B properties exhibit similar dynamics, except that San Francisco Class B expectations are declining. Class C expectations are more significantly affected by post-pandemic market conditions.

#### 6.2.4 Lease Type

Figure 12 shows expectations for gross, modified gross, and NNN leases. The key difference between these types is that NNN leases remove the risk of operating cost inflation from landlord cash flows, while gross leases leave cost inflation risk with the landlord. Modified gross leases fall anywhere between pure NNN and pure gross leases. Gross leases are common for office properties (74% in Table A1).

Gross leases, the major lease type for office properties, exhibit stable and rigid expectations, consistent with high-quality leases (larger leases in newer, Class A properties). We do not observe any significant increase in expectations in the post-pandemic inflationary economic environment.

Characteristics of modified gross leases vary by market: modified gross leases are similar to gross leases in New York City but very different from gross leases in Washington DC and San Francisco.

Triple-net leases in New York are noisy due to small sample size, while they show stable expectations in Washington DC and San Francisco. There is no significant difference in growth rates between gross and NNN leases, implying that operating expense inflation is not separately priced in lease negotiations.

### 6.3 Submarket Analysis

Given the highly localized nature of real estate markets, submarket-level analysis provides valuable insight for gauging expectations. Within the same city, different submarkets (e.g., downtown vs. suburban office nodes) can exhibit distinct demand–supply dynamics,

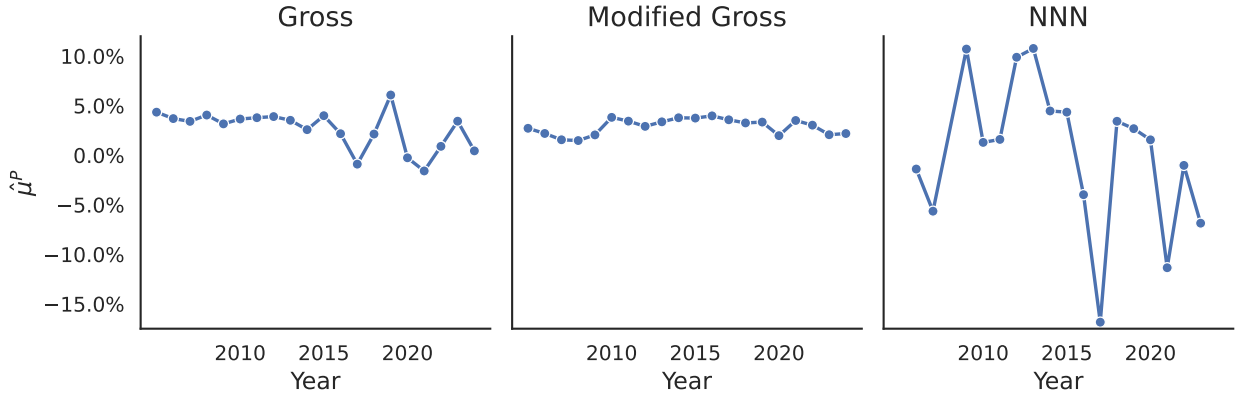
Figure 11: **Office Growth Expectations by Building Class**



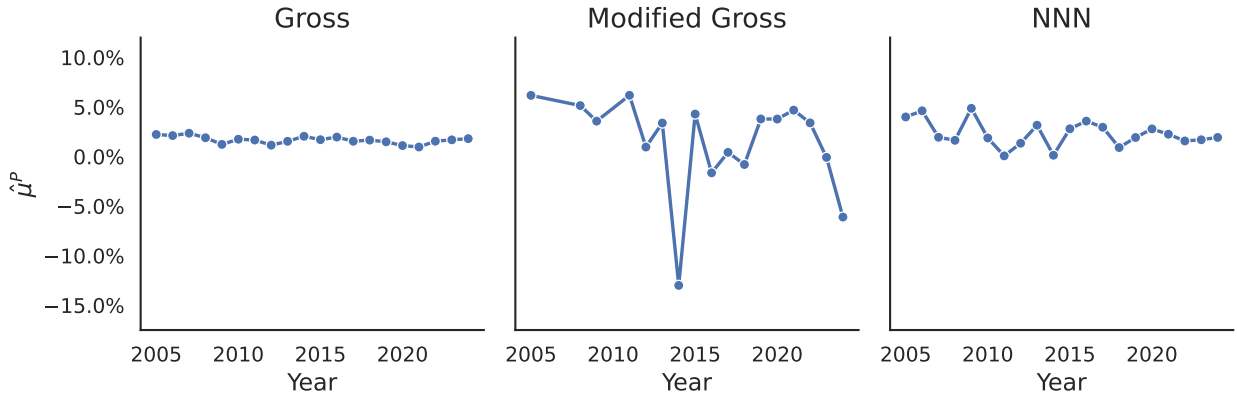

*Note:* This figure shows the average growth expectations $\hat{\mu}_t^P$ estimated annually for Classes A, B, and C in three office markets: (a) New York City, (b) Washington DC, and (c) San Francisco Bay Area. These classifications are regarded as an aggregate quality measure. Class A properties comprise 59% of the office sample (Table A1).

Figure 12: **Office Growth Expectations by Lease Type**

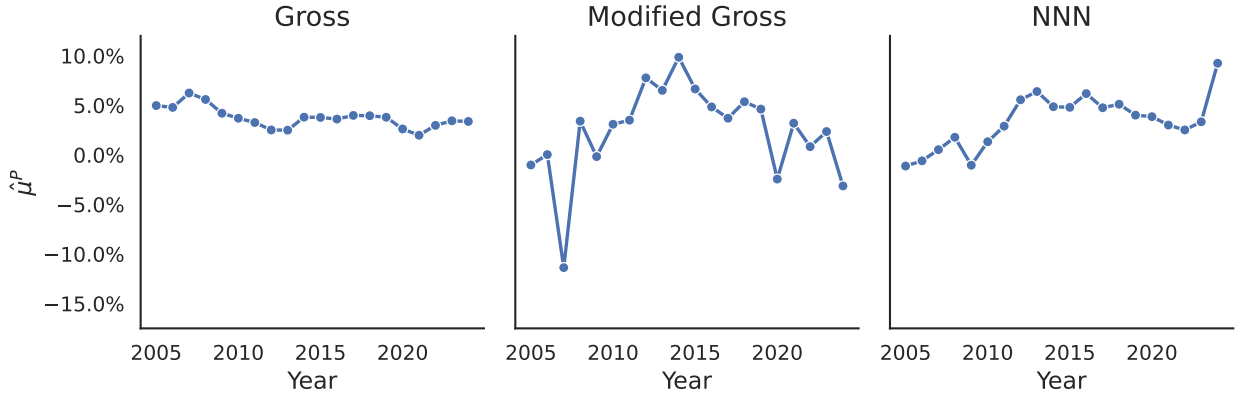
(a) New York City




(b) Washington DC




(c) San Francisco Bay Area




*Note:* This figure shows the average growth expectations $\hat{\mu}_t^P$ estimated annually for gross, modified gross, and triple-net (NNN) leases in three office markets: (a) New York City, (b) Washington DC, and (c) San Francisco Bay Area.

tenant composition, vacancy rates, and development pipelines. To better capture this heterogeneity in expectations, we conduct a case study of the San Francisco Bay Are office market, estimating SRIs and rent-growth expectations at the submarket level. We focus on six major submarkets—North Financial District, South Financial District, Oakland, Walnut Creek, San Mateo, and North San Jose—and estimate SRIs and rent-growth expectations.

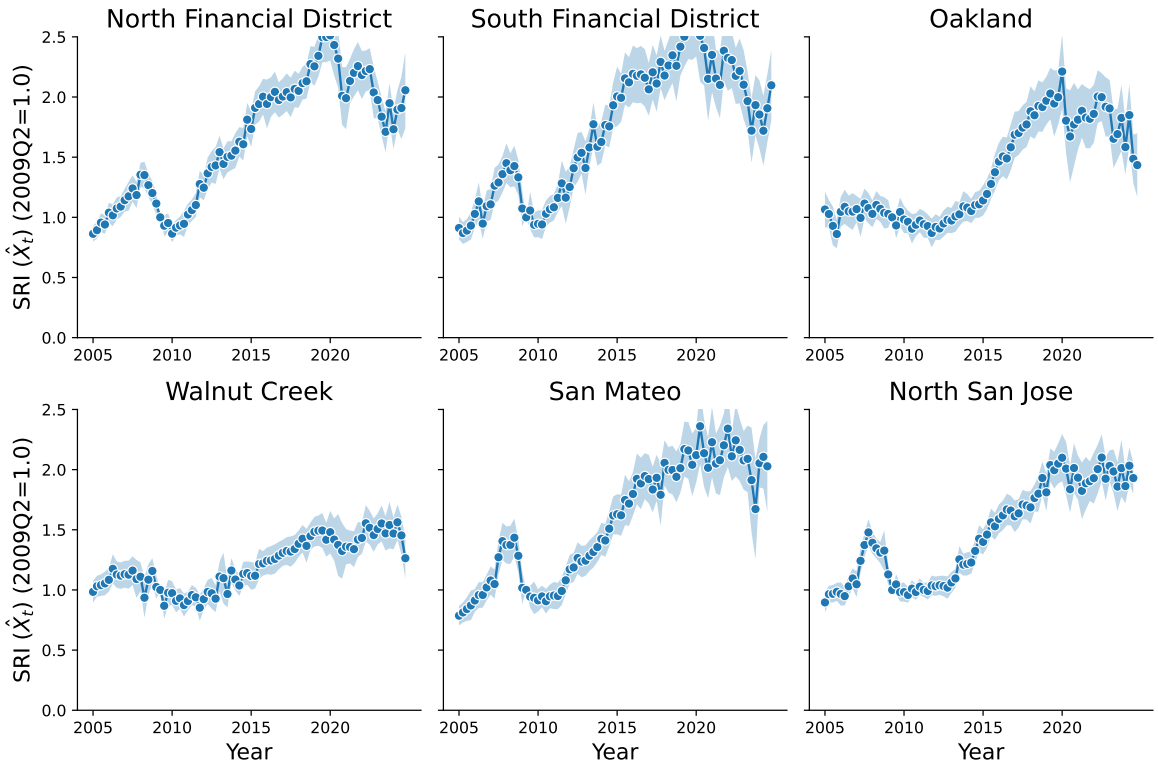
Figure 13 plots the estimated submarket-specific SRIs for the San Francisco Bay Are. We observe substantial heterogeneity in SRI dynamics across submarkets within the same market. First, submarkets exhibit different cyclical responses. For example, the suburban Walnut Creek submarket shows little reaction to either the GFC or pandemic, whereas the five urban submarkets respond more strongly. Even among the urban submarkets, responses differ: Oakland shows only a modest GFC effect, while San Mateo declines substantially after the GFC; during the pandemic, the pattern reverses. Second, trend growth also varies across submarkets, with a clear contrast between the suburban area (Walnut Creek) and the city submarkets.

Figure 14 plots the distribution of estimated risk-neutral rent-growth expectations across major submarkets in the San Francisco Bay Are. Consistent with the heterogeneity in SRI dynamics, expectations also differ across submarkets. For example, Walnut Creek—which exhibits slower SRI growth—shows lower mean and median expectations. By contrast, the North Financial District, South Financial District, and San Mateo display higher expectations, in line with their stronger SRI growth. These results reinforce the link between SRI dynamics and market expectations and underscore the highly localized nature of commercial real estate markets.

## 6.4 Decomposition of Expectations and Risk Premiums

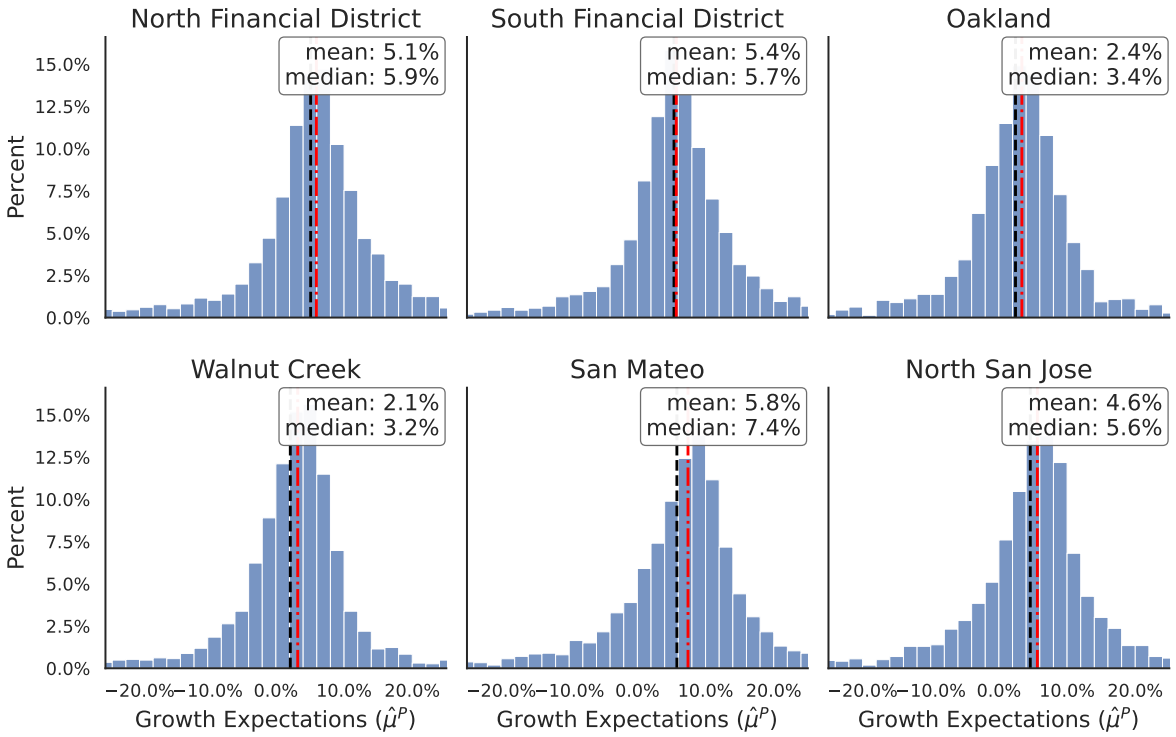
We estimate unconditional growth expectations under the physical probability measure $P$ (denoted $\hat{\mu}^P$) but cannot estimate time-varying conditional expectations under $P$. In contrast, we estimate conditional growth expectations under the risk-neutral probability

Figure 13: **Sub-Market Office SRIs**




*Note:* This figure plots the estimated submarket-specific SRIs in major submarket in San Francisco Bay Are. The dots indicate the point estimates of quarterly SRIs, while the shaded bands represent the corresponding confidence intervals based on ±2 standard errors. The SRI is normalized to 1.00 in 2009 Q2 in each market.

Figure 14: **Distribution of Office Rent Growth Expectations**




*Note:* This figure displays the distribution of estimated rent-growth expectations under the physical probability measure $P$ across major submarket in San Francisco Bay Are, with the mean (black) and median (red) indicated.

measure $Q$ (denoted $\hat{\mu}_{it}^{Q}$) from individual leases. Two approaches can relate these estimates.

The first approach, which we adopt, assumes a constant risk premium $\lambda\sigma$. We calculate unconditional risk-neutral expectations via iterated expectations as $\hat{\mu}^{Q} = E[\hat{\mu}_{it}^{Q}]$, estimate the unconditional risk premium as the difference $\lambda\sigma = \hat{\mu}^{P} - \hat{\mu}^{Q}$, and recover conditional physical expectations as $\hat{\mu}_{it}^{P} = \hat{\mu}_{it}^{Q} + \lambda\sigma$. This approach allows us to trace the time path of conditional expectations under $P$ while maintaining a stable risk premium.

The second approach assumes constant physical expectations $\hat{\mu}^{P}$ with time-varying risk premiums, calculating conditional risk premiums as $\lambda_{it}\sigma = \hat{\mu}^{P} - \hat{\mu}_{it}^{Q}$. This approach attributes all temporal variation in risk-neutral expectations to changes in risk premiums rather than changes in physical expectations.

In reality, both expectations and risk premiums likely vary over time. Separately identifying time-varying conditional expectations and risk premiums would require additional data to directly estimate conditional expectations under $P$, such as survey-based forecasts or high-frequency transaction data that could reveal market participants' evolving beliefs about future rent growth.

# 7 Conclusion

This paper develops a novel framework to extract commercial real estate rent levels, growth expectations, and risk premiums from long-term lease contracts across major U.S. markets. Our approach yields three main contributions to understanding real estate valuation and expectations formation.

First, we construct a Spot Rent Index (SRI) that captures instantaneous rental prices free from lease-term effects for office, industrial, and retail properties at both national and market levels. The SRI exhibits substantially richer dynamics with greater sensitivity to market conditions than existing rent indicators, tracking major macroeconomic episodes, such as the Global Financial Crisis and the COVID-19 pandemic. We also document substan-

tial heterogeneity across property types and markets, with office rents showing pronounced post-pandemic stagnation while industrial rents maintain strong, sustained growth. This constant-quality index provides a more accurate measure of rental market fundamentals than traditional indices based on transaction prices or appraisals.

Second, by applying a no-arbitrage framework to long-term leases, we provide the first systematic measures of forward-looking beliefs in commercial real estate, an essential yet illiquid asset class that has long lacked reliable expectation estimates. Our estimates reveal that growth expectations embedded in long-term leases are considerably more stable than realized rent growth, especially for large leases in newer class A properties. This rigidity leads expectations to consistently overestimate actual growth during downturns and underestimate it during recoveries, potentially reflecting tenants' long-term inelastic demand for specific space types. In contrast, expectations respond to market conditions for smaller leases in older and lower class properties due to their marginal nature.

Third, we estimate rent growth risk premiums by exploiting the wedge between physical and risk-neutral rent growth expectations from long-term leases. Our unconditional estimates (1.6% for office, 4.7% for industrial, and $-3.3\%$ for retail properties) reveal how investors price rental income uncertainty. These risk premiums vary substantially across markets and correlate with local fundamentals such as tenant composition and rent volatility, demonstrating how uncertainty is capitalized into long-term lease rates. We further decompose these premiums into the market price of risk and volatility, providing insights into the sources of risk compensation across property types.

Our framework offers practical applications for real estate valuation, portfolio management, and policy monitoring. Practitioners can use our SRI and expectation measures to improve market assessments, calibrate valuation models, and evaluate investment opportunities at both national and submarket levels. Policymakers can leverage these expectations to monitor commercial real estate market sentiment and potential vulnerabilities, particularly given the elevated long-run rent growth expectations we document that may have

implications for inflation dynamics.

Several promising directions emerge for future research. First, extending our framework to incorporate time-varying volatility and risk premiums would allow for richer dynamics in expectation formation and risk pricing. Second, linking our rent growth expectations and risk premiums to property-level fundamentals, such as vacancy rates, tenant credit quality, and capital expenditures, could deepen understanding of the drivers of rental income risk. Third, expanding coverage to additional property types and smaller markets would provide a more comprehensive view of commercial real estate dynamics across the United States. Finally, exploring connections between our market-based expectation measures and macroeconomic conditions could shed light on transmission mechanisms between the broader economy and commercial real estate markets.

More broadly, by providing market-specific, long-horizon measures of expected rent growth and risk premiums derived from actual lease contracts, this study establishes a methodological foundation for future research on real estate investment, valuation, and expectations formation in settings where forward-looking information has historically been scarce. Our approach demonstrates how rich contractual data can be leveraged to overcome traditional measurement challenges in illiquid asset markets, with potential applications extending beyond commercial real estate to other settings with long-term cash flow contracts.

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# Appendix A Proof

## A.1 Derivation of Equation (15)

The value of a long-term lease $V_{it}$ equals the present value of rolled-over spot rents. However, a critical distinction must be made between the spot rent process and the lease valuation. The spot rent process (Equation (14)) represents a constant-quality index that tracks the spot rent for a hypothetical building of fixed age and quality. In contrast, a long-term lease is a claim on the rental income from a specific building that physically ages and deteriorates over the lease term. As the building ages, its rental rate growth lags the growth of the constant-quality benchmark due to physical depreciation, functional obsolescence, and competitive disadvantage against newer properties. Thus, the spot rent growth for a specific building needs to be adjusted downward by the rent depreciation rate $\delta$. Equivalently, the discount rate needs to be adjusted upward by adding the rent depreciation rate $\delta$.

Assuming a constant risk-free interest rate $\bar{r}_t$ over the lease term and $\bar{r}_t + \delta \neq \mu^Q$, the present value of a lease in Equation (11) is expressed as follows:

$$
\begin{aligned}
V_{it} &= E_t^Q \int_t^{T_{it}} e^{-(\bar{r}_t+\delta)(s-t)} X_{is}\, ds \\
&= X_i \cdot e^{Z_{it}'\beta} \cdot \int_t^{T_{it}} e^{-(\bar{r}_t+\delta)(s-t)} \cdot E_t^Q X_s\, ds \\
&= X_i \cdot e^{Z_{it}'\beta} \cdot \int_t^{T_{it}} e^{-(\bar{r}_t+\delta)(s-t)} \cdot X_t \cdot e^{\mu^Q(s-t)}\, ds \\
&= X_t \cdot X_i \cdot e^{Z_{it}'\beta} \cdot \int_t^{T_{it}} e^{-(\bar{r}_t+\delta-\mu^Q)(s-t)}\, ds \\
&= X_t \cdot X_i \cdot e^{Z_{it}'\beta} \cdot \int_0^{T_{it}-t} e^{-(\bar{r}_t+\delta-\mu^Q)u}\, du \\
&= X_t \cdot X_i \cdot e^{Z_{it}'\beta} \cdot \frac{1 - e^{-(\bar{r}_t+\delta-\mu^Q)\tau_{it}}}{\bar{r}_t + \delta - \mu^Q} \\
&= X_{it} \cdot \frac{1 - e^{-(\bar{r}_t+\delta-\mu^Q)\tau_{it}}}{\bar{r}_t + \delta - \mu^Q}.
\end{aligned}
\tag{A.1}
$$

Rewriting Equation (A.1) in terms of the effective rent by plugging in Equation (3),

$$R^e_{it} = X_{it} \cdot \frac{1 - e^{-(\bar{r}_t + \delta - \mu^Q)\tau_{it}}}{\bar{r}_t + \delta - \mu^Q} \left( \frac{1 - e^{-\bar{r}_t \tau_{it}}}{\bar{r}_t} \right)^{-1}. \tag{A.2}$$

Equation (A.2) is equivalent to

$$R^e_{it} \frac{1 - e^{-\bar{r}_t \tau_{it}}}{\bar{r}_t} - X_{it} \frac{1 - e^{-(\bar{r}_t + \delta - \mu^Q)\tau_{it}}}{\bar{r}_t + \delta - \mu^Q} = 0. \tag{A.3}$$

## A.2 Insensitivity of Equation (15)

The present value term in Equations (15) and (A.3) becomes insensitive to $\mu$ and $\mu^Q$, respectively, as the lease term approaches zero.

$$\lim_{\tau_{it} \to 0} \partial \left( \frac{1 - e^{-(\bar{r}_t + \delta - \mu)\tau_{it}}}{\bar{r}_t + \delta - \mu} \right) \Big/ \partial \mu = \lim_{\tau_{it} \to 0} \frac{\tau_{it}}{2} = 0. \tag{A.4}$$

## A.3 Equivalence of Risk Premiums

From Equation (A.1), the present value of a lease is expressed:

$$V_{it} = X_{it} \cdot \frac{1 - e^{-\left(\bar{r}_t + \delta - \mu^Q\right)(T_{it} - t)}}{\bar{r}_t + \delta - \mu^Q}.$$

Equivalently, using Equation (13), we can express the same lease value under probability measure $P$:

$$V_{it} = X_{it} \cdot \frac{1 - e^{-\left(\bar{r}_t + \delta + p^r - \left(\mu^Q + \lambda\sigma\right)\right)(T_{it} - t)}}{\bar{r}_t + \delta + p^r - (\mu^Q + \lambda\sigma)}, \tag{A.5}$$

where $p^r$ denotes the return risk premium. Because the lease present value is identical in both equations, we obtain

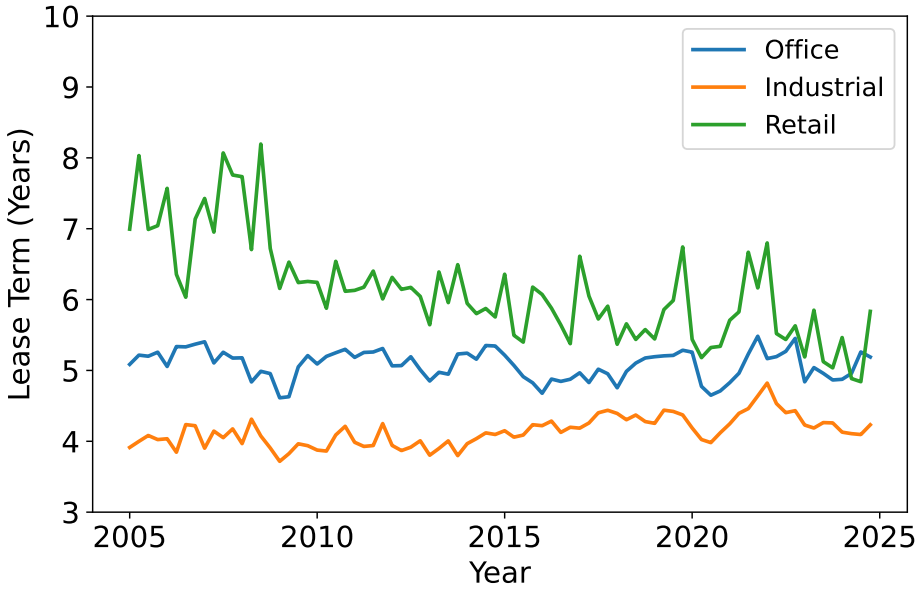
$$p^r = \lambda\sigma. \tag{A.6}$$

In other words, the estimated rent risk premium also represents the return risk premium.

# Appendix B Additional Figures

## B.1 Data Description

Figure A1: **Average Lease Term Over Time**

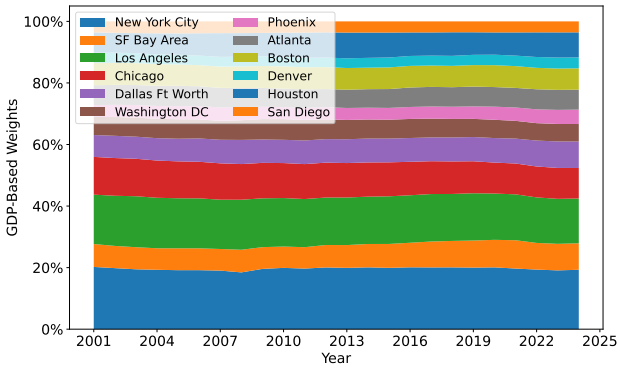



*Note:* This figure plots the quarterly average lease term in each property type.

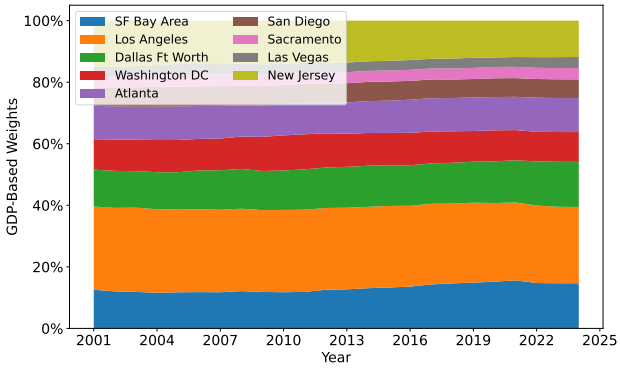
## B.2 National Index Weight

Figure A2: **GDP Weight Across Market**

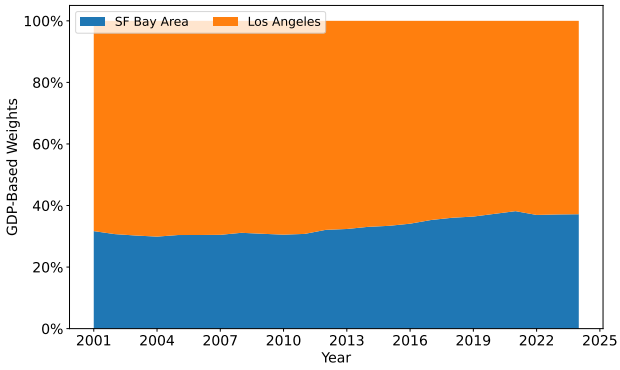
(a) Office




(b) Industrial




(c) Retail

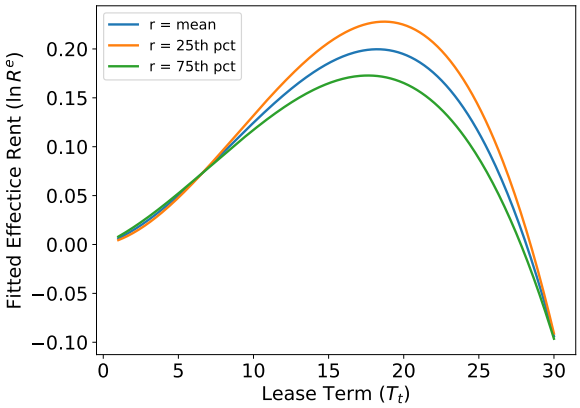



*Note:* This figure shows the market GDP weight for each market by year. The weights at the beginning of the sample period are used as constant cross-market weights to estimate the national SRI.

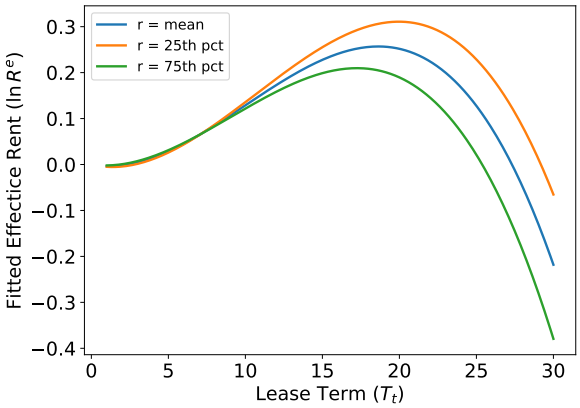
## B.3 Fitted Term Structures

Figure A3: **GDP Weight Across Market**

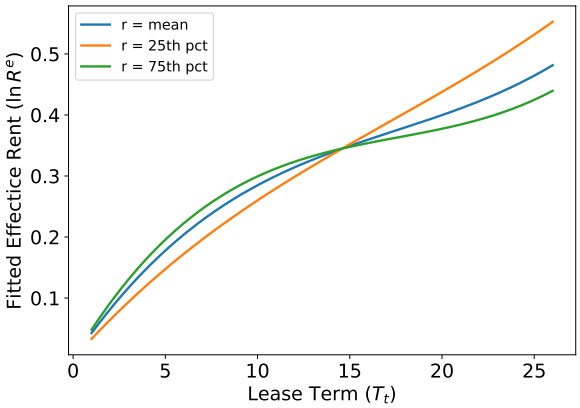
(a) Office




(b) Industrial




(c) Retail




*Note:* This figure shows the term structure of effective rent, fitted using a cubic function of lease terms, for each property type.

## B.4 Market-Specific SRIs

We estimate SRIs for major U.S. markets: twelve office, nine industrial, and three retail markets. Specifically, we apply the panel regression in Equation (7) separately to each market and plot the resulting estimates.

Figure A4 shows the results. The dots denote quarterly SRIs, while the shaded bands represent ±2 standard error confidence intervals. There are notable similarities as well as differences across markets.[5]

Markets differ in their responses to macroeconomic cycles. Several major markets were significantly affected by the GFC in 2009, with large declines in SRIs in New York City, the San Francisco Bay Area, Los Angeles, and Boston. By contrast, estimated SRIs did not decline markedly in Chicago, Atlanta, Dallas Fort Worth, or Washington, DC. This heterogeneity also appears in the response to the pandemic in 2020. For example, Washington, DC experienced limited impact, perhaps because its tenant base and local economy are driven by the public sector, which makes SRIs less pro-cyclical.

Markets also exhibit heterogeneous growth in SRIs over the sample period. The San Francisco Bay Area's SRI approximately doubled before the pandemic relative to the 2009 Q2 value. By contrast, Washington, DC shows little growth in SRI over the two decades. Restricting attention to New York City and Boston during 2006–2018, the estimated SRI dynamics are similar to those reported by Aldana et al. (2025), which use a Kalman filter–based approach. This provides partial validation of the robustness of the estimated SRI beyond anecdotal accounts for individual markets.

Figure A4b plots market-specific SRIs for nine major industrial markets and three major retail markets. Panel (a) reveals substantial heterogeneity in SRI dynamics across industrial markets, similar to what we find in the office sector. Importantly, dynamics across macroeconomic cycles differ: the GFC depressed the index, particularly in the San Francisco Bay Are, Los Angeles, San Diego, and Las Vegas, whereas the pandemic brought pronounced

[5]Time series of year-over-year growth rates are shown in Figure A5 in Appendix B.

Figure A4: **Market-Specific SRIs (continued on next page)**

(a) Office

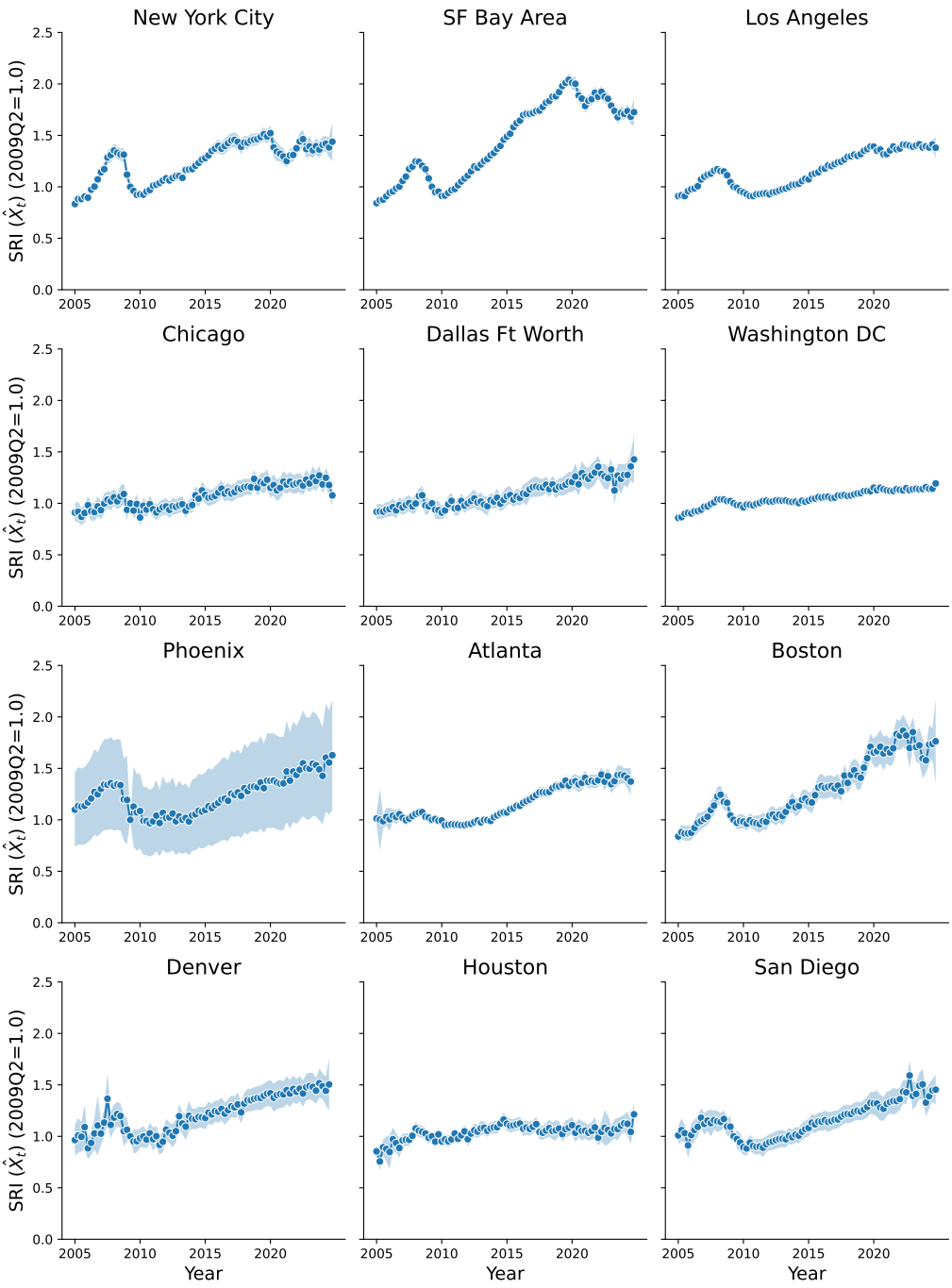
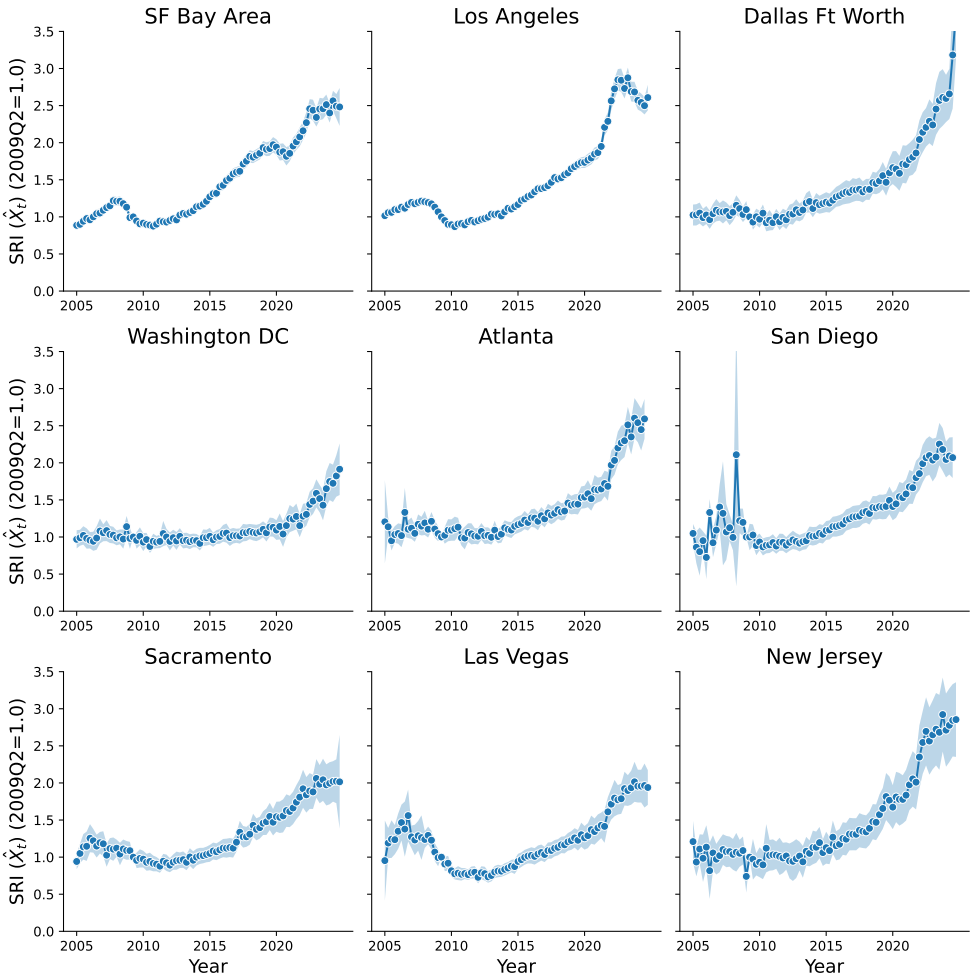
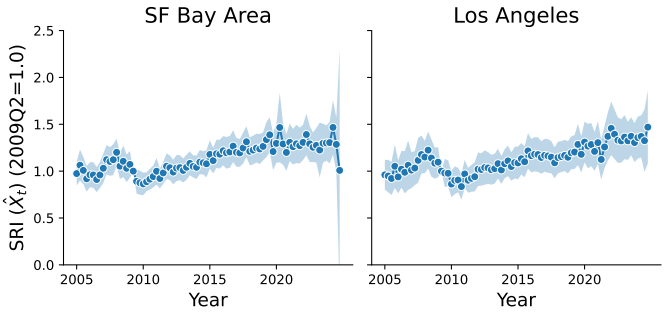


Figure A4: **Market-Specific SRIs (continued)**

(b) Industrial




(c) Retail Property




*Note:* This figure plots the estimated market-specific SRIs in major U.S. markets. The dots indicate the point estimates of quarterly SRI, while the shaded bands represent the corresponding confidence intervals based on ±2 standard errors. The SRI is normalized to 1.00 in 2009 Q2 in each market.

inflationary pressures in all industrial markets. The magnitude of the SRI changes is also significantly larger in the post-pandemic period than during the GFC.

Panel (c) presents a more nuanced picture for retail SRIs. First, New York SRI is noisy due to a small sample size. Second, we observe similar SRI dynamics in the San Francisco Bay Are and Los Angeles. This similarity likely reflects the geographical proximity of these markets; it does not imply that retail SRI dynamics are homogeneous across markets. This also suggests that our national SRI for retail properties is primarily driven by the California markets due to a limited sample, which may not be nationally representative. We discuss the usefulness of the market SRI as a price measure in the next section.

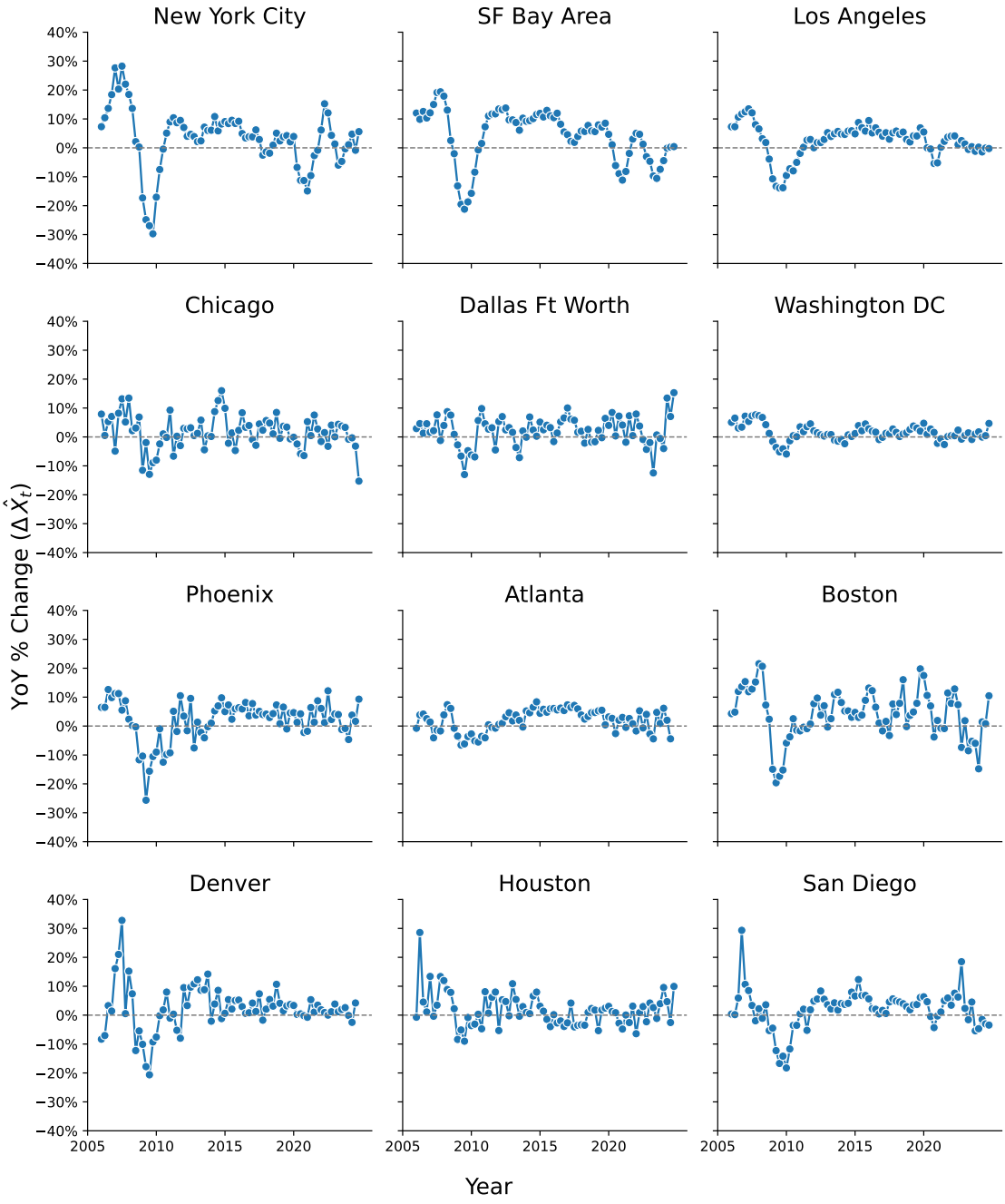
Based on the estimated ex-post SRIs, we conclude that their dynamics are highly heterogeneous. This heterogeneity stems from differences in market-specific office demand and supply structures, as modeled in Grenadier (1995). Rather than diving into those mechanisms, we focus on equilibrium spot rent dynamics and measure both ex-post and ex-ante rent drifts in the next section.

## B.5 Distribution

Using the same method as for the national data, we estimate both unconditional expectations under physical measure $P$ and forward-looking expectations under risk-neutral measure $Q$ for major U.S. markets.

Figure A6 shows the distribution of ex-ante rent growth expectations converted to the physical measure $P$ across major U.S. markets. We first estimate the distribution under the risk-neutral measure $Q$ from individual lease data, then convert it to the one under the physical measure $P$ by adding the estimated risk premium for each market (reported in Table 5). This conversion allows for comparison with ex-post expectations from the historical SRI dynamics. The figure displays mean and median values for each market. For office properties, mean rent growth rates range from 1.2% in Washington DC to 3.6% in the San Francisco Bay Area. Mean growth rates are slightly lower due to left skewness in the distributions.

Figure A5: **Market-Specific Office SRIs - YoY Change**




*Note:* This figure plots the estimated year-over-year (YoY) change of quarterly SRI in major U.S. markets.

For industrial properties, mean expected growth rates range from 4.1% in Washington DC to 8.9% in San Diego. For retail properties, expected rates range from 1.3% in the San Francisco Bay Area to 3.4% in Los Angeles.

Figure A6: **Distribution of Office Rent Growth Expectations (continued on next page)**

(a) Office

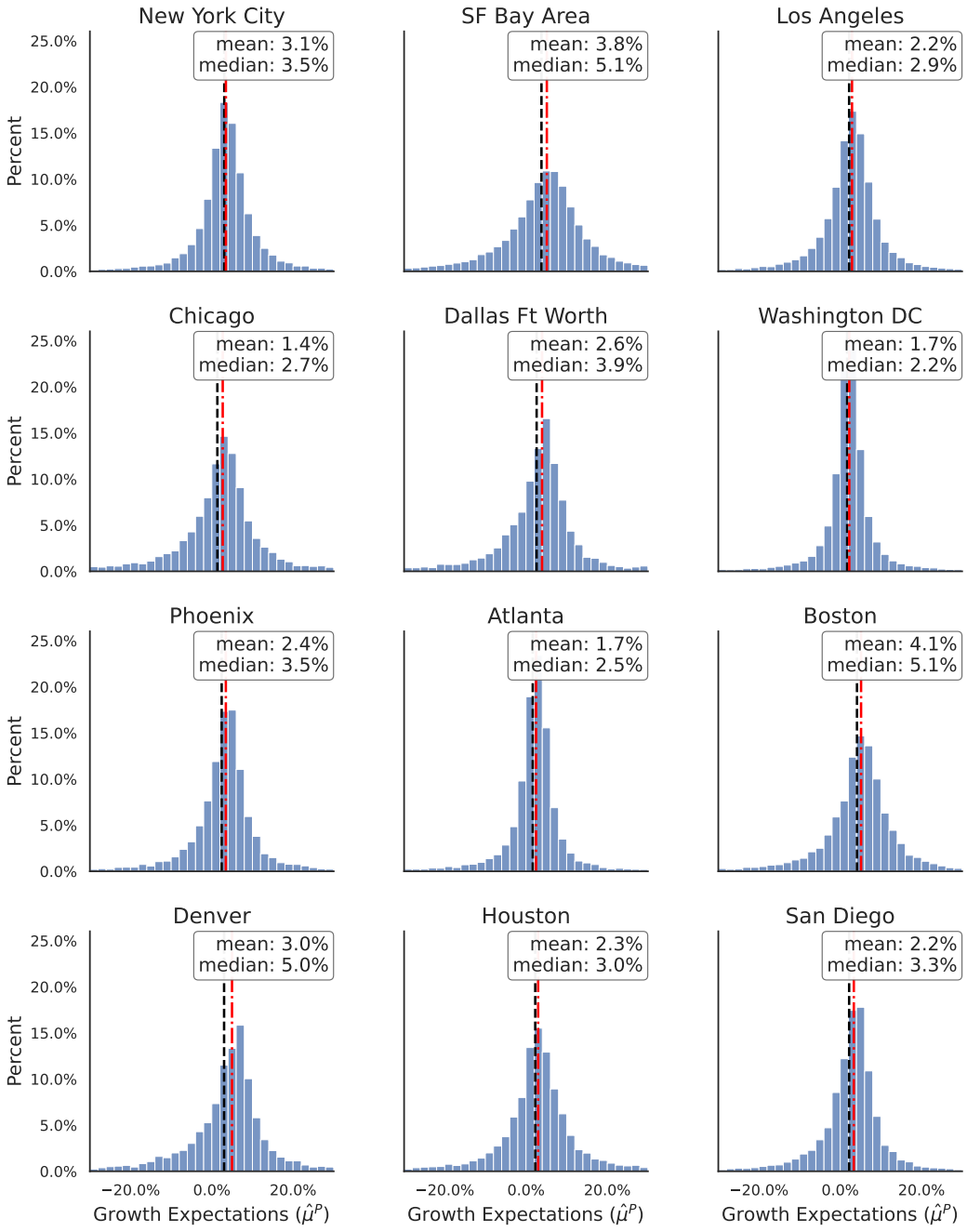
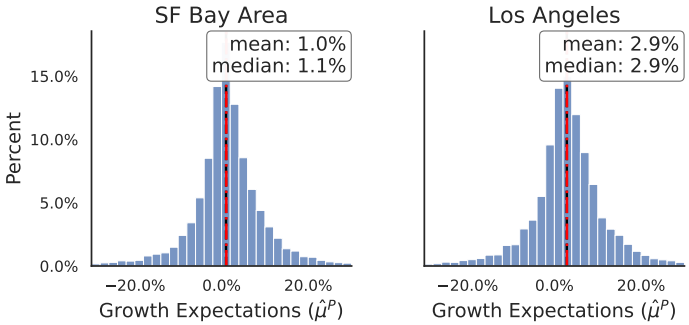


Figure A6: **Distribution Rent Growth Expectations (continued)**

(b) Industrial




(c) Retail




*Note:* This figure displays the distribution of estimated rent-growth expectations under the physical probability measure $P$ across major U.S. markets, with the mean (black) and median (red) indicated.

Beyond means and medians, markets also differ in the dispersion of the ex-ante expectations. Markets such as New York City, the San Francisco Bay Area, and Boston exhibit wider dispersion, whereas Washington, DC, and Atlanta show narrower dispersion. This pattern is consistent with ex-post SRI volatility: New York City and the San Francisco Bay Area display more volatile SRIs. Thus, the distribution of ex-ante expectations appears correlated with ex-post market SRI volatility across markets.

## B.6 Dynamics

Figure A7 plots the time series of market-level mean growth rates by year by assuming a constant risk premium. Importantly, recently contracted leases provide forward-looking rent expectations, because typical lease terms exceed 5 years.

In the New York office market, the expected growth rate fell below $-2\%$ since 2022. Although the NYC office SRI did not show a significant decline through 2024 (Figure A4), recent leases incorporated anticipated future rent declines. Similarly, expected office rent growth turned negative in Los Angeles, Chicago, Washington DC, Atlanta, and San Diego. Other markets also show declining expectations, though rates remain positive. The GFC (2008–2009) similarly generated negative growth expectations in markets such as Chicago, Boston, and Dallas-Fort Worth, though the magnitudes were smaller. Following the GFC, markets such as the San Francisco Bay Area and Dallas Fort Worth experienced significant rent increases. Overall, while mean expectations appear pro-cyclical in some markets, the cross-market heterogeneity in expectations is notably greater than the heterogeneity in realized SRI.

Industrial rent growth expectations tend to exhibit upward trends, particularly in the San Francisco Bay Area, Los Angeles, Atlanta, and New Jersey. After the pandemic, there is substantial heterogeneity in the responses across markets: areas such as the San Francisco Bay Area, Dallas–Fort Worth, and Washington, D.C. experienced significant declines in growth expectations, whereas markets such as Sacramento and Las Vegas showed notable

Figure A7: **Dynamics of Rent Growth Expectations (continued on next page)**

(a) Office

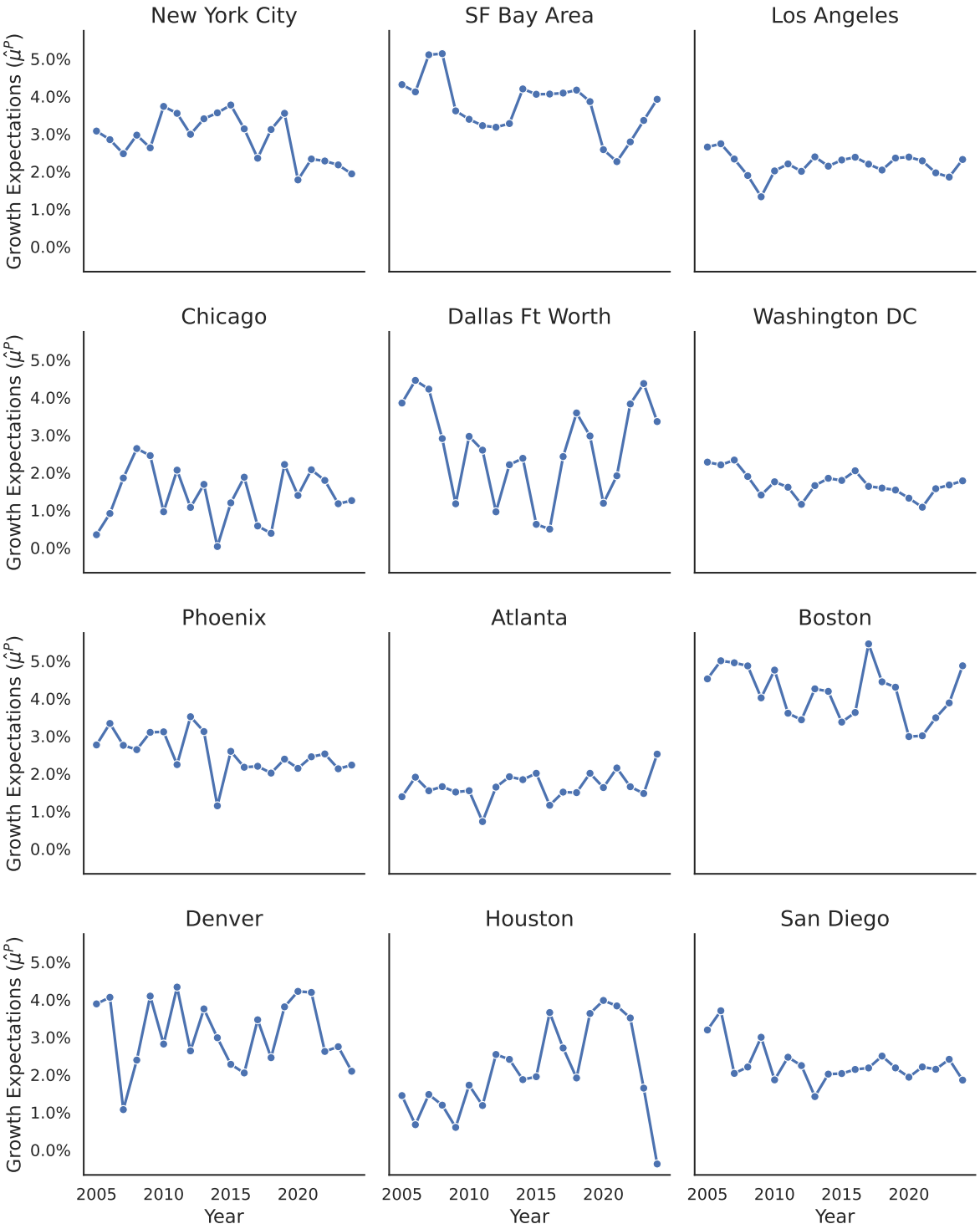
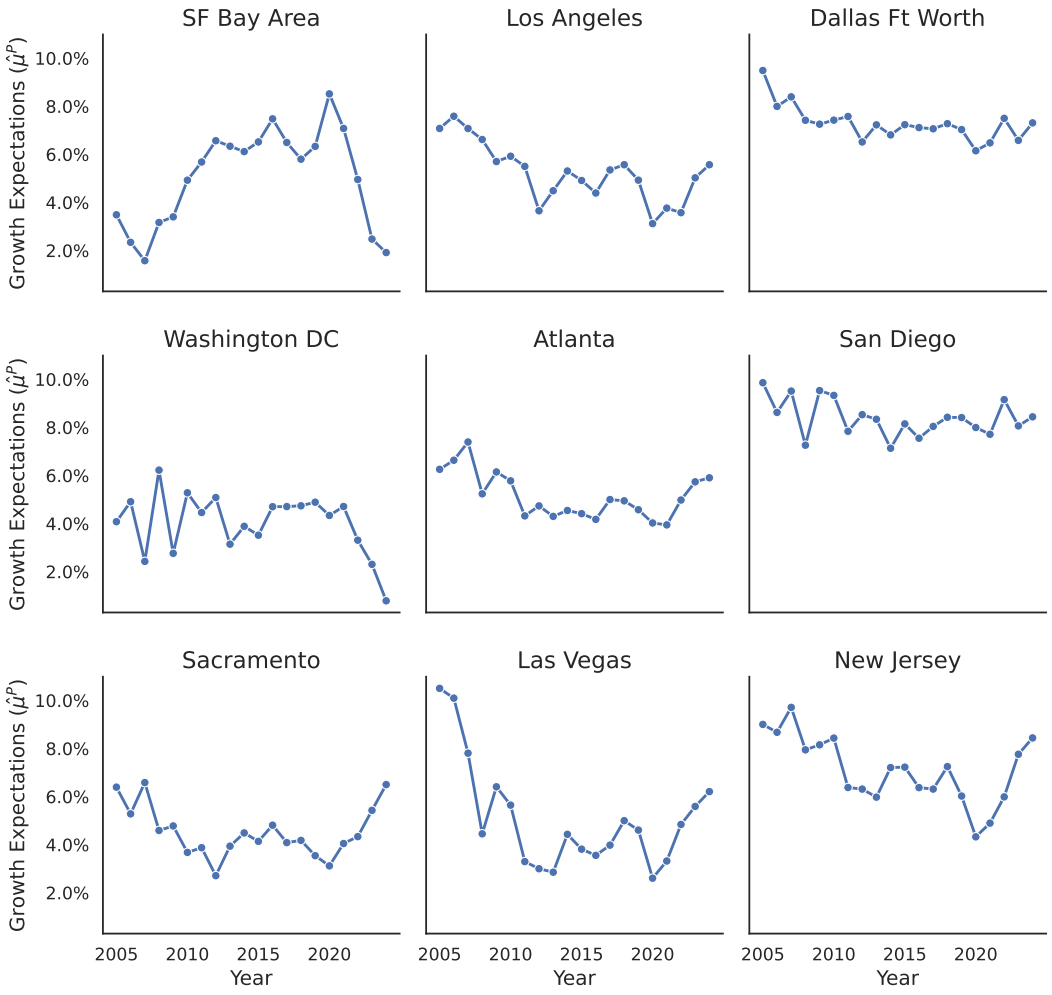
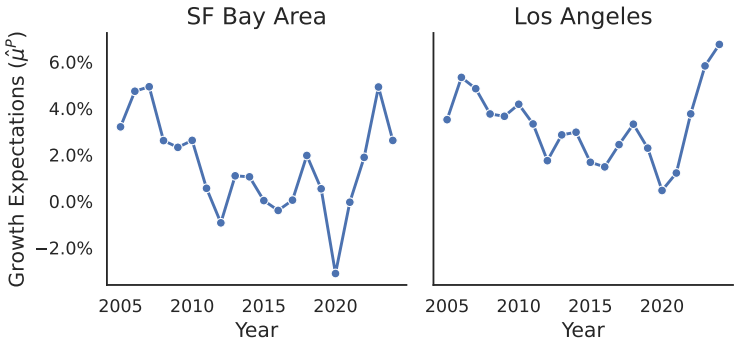


Figure A7: **Dynamics of Rent Growth Expectations (continued)**

(b) Industrial




(c) Retail




*Note:* This figure plots the time series of the mean estimated rent-growth expectations under the physical probability measure $P$ for major U.S. markets.

increases. For retail markets, rent growth expectations are relatively stable, with modest declines after the pandemic, except for the noisy results observed for New York City.

# Appendix C Additional Tables

Table A1: **Summary Statistics (Office)**

| | Mean | SD | Min | Median | Max |
|---|---|---|---|---|---|
| Lease Term (years) | 5.06 | 3.05 | 1.00 | 5.00 | 30.00 |
| Effective Rent ($/sqft/year) | 36.11 | 19.52 | 5.28 | 31.08 | 326.31 |
| Lease Size (sqft) | 9,350.59 | 16,501.51 | 166.00 | 4,003.00 | 264787.00 |
| Initial Rent ($/sqft/year) | 36.03 | 19.15 | 5.28 | 31.00 | 300.00 |
| Annual Escalation (%) | 1.66 | 1.45 | -3.04 | 2.47 | 16.82 |
| Free Rent (months) | 2.28 | 3.32 | 0.00 | 1.00 | 37.00 |
| TI Allowance ($/sqft) | 14.53 | 26.79 | 0.00 | 0.00 | 467.00 |
| Concession Ratio (%) | 3.68 | 4.26 | 0.00 | 1.85 | 25.16 |
| Present Value ($/sqft) | 2,152.17 | 2,126.26 | 63.11 | 1,535.73 | 52,286.07 |
| Sublease (1/0) | 0.06 | 0.24 | 0.00 | 0.00 | 1.00 |
| Lease: Gross (1/0) | 0.74 | 0.44 | 0.00 | 1.00 | 1.00 |
| Lease: Modified Gross (1/0) | 0.13 | 0.33 | 0.00 | 0.00 | 1.00 |
| Lease: NNN (1/0) | 0.13 | 0.33 | 0.00 | 0.00 | 1.00 |
| Transaction: New Lease (1/0) | 0.54 | 0.50 | 0.00 | 1.00 | 1.00 |
| Transaction: Renewal (1/0) | 0.25 | 0.43 | 0.00 | 0.00 | 1.00 |
| Transaction: Extension (1/0) | 0.08 | 0.27 | 0.00 | 0.00 | 1.00 |
| Renovation-adjusted Age (years) | 24.46 | 19.55 | 0.00 | 22.00 | 141.00 |
| Building Class: A (1/0) | 0.55 | 0.50 | 0.00 | 1.00 | 1.00 |
| Building Class: B (1/0) | 0.41 | 0.49 | 0.00 | 0.00 | 1.00 |
| Building Class: C (1/0) | 0.04 | 0.19 | 0.00 | 0.00 | 1.00 |
| Tenant Industry: Health (1/0) | 0.10 | 0.29 | 0.00 | 0.00 | 1.00 |
| Tenant Industry: Finance (1/0) | 0.09 | 0.29 | 0.00 | 0.00 | 1.00 |
| Tenant Industry: Legal (1/0) | 0.08 | 0.27 | 0.00 | 0.00 | 1.00 |
| Tenant Industry: Software (1/0) | 0.08 | 0.26 | 0.00 | 0.00 | 1.00 |
| Tenant Industry: Commercial (1/0) | 0.06 | 0.24 | 0.00 | 0.00 | 1.00 |
| Tenant Industry: Media (1/0) | 0.05 | 0.23 | 0.00 | 0.00 | 1.00 |
| Tenant Industry: Real Estate (1/0) | 0.05 | 0.21 | 0.00 | 0.00 | 1.00 |
| Tenant Industry: Insurance (1/0) | 0.03 | 0.17 | 0.00 | 0.00 | 1.00 |
| Tenant Industry: Non-Profit (1/0) | 0.03 | 0.16 | 0.00 | 0.00 | 1.00 |
| Tenant Industry: Unknown (1/0) | 0.24 | 0.43 | 0.00 | 0.00 | 1.00 |
| Unique Properties | 18,265 | | | | |
| N | 194,025 | | | | |

*Note:* This table reports summary statistics for office lease contracts in the full sample. Initial rent and TI allowance are expressed as unit rent per square foot. Annual growth refers to the constant yearly rate at which initial rent would need to increase to reach the final rent by the end of the lease term. It is calculated as the compound annual growth rate.

Table A2: **Summary Statistics (Industrial Property)**

| | Mean | SD | Min | Median | Max |
|---|---|---|---|---|---|
| Lease Term (years) | 5.98 | 3.38 | 1.00 | 5.00 | 26.00 |
| Effective Rent ($/sqft/year) | 32.99 | 17.90 | 5.85 | 28.96 | 147.42 |
| Lease Size (sqft) | 3,814.68 | 6,590.93 | 298.00 | 1,700.00 | 72,100.00 |
| Initial Rent ($/sqft/year) | 32.16 | 16.90 | 5.90 | 28.56 | 144.00 |
| Annual Escalation (%) | 1.29 | 1.44 | 0.00 | 0.00 | 7.17 |
| Free Rent (months) | 0.91 | 1.75 | 0.00 | 0.00 | 18.00 |
| TI Allowance ($/sqft) | 5.49 | 15.18 | 0.00 | 0.00 | 214.00 |
| Concession Ratio (%) | 1.61 | 2.75 | 0.00 | 0.00 | 15.64 |
| Present Value ($/sqft) | 2,304.99 | 2,013.86 | 74.06 | 1,701.58 | 22,955.75 |
| Sublease (1/0) | 0.01 | 0.09 | 0.00 | 0.00 | 1.00 |
| Lease: Gross (1/0) | 0.10 | 0.30 | 0.00 | 0.00 | 1.00 |
| Lease: Modified Gross (1/0) | 0.08 | 0.27 | 0.00 | 0.00 | 1.00 |
| Lease: NNN (1/0) | 0.82 | 0.38 | 0.00 | 1.00 | 1.00 |
| Transaction: New Lease (1/0) | 0.50 | 0.50 | 0.00 | 1.00 | 1.00 |
| Transaction: Renewal (1/0) | 0.10 | 0.30 | 0.00 | 0.00 | 1.00 |
| Transaction: Extension (1/0) | 0.02 | 0.13 | 0.00 | 0.00 | 1.00 |
| Renovation-adjusted Age (years) | 27.12 | 22.64 | 0.00 | 24.00 | 120.00 |
| Building Class: A (1/0) | 0.06 | 0.24 | 0.00 | 0.00 | 1.00 |
| Building Class: B (1/0) | 0.15 | 0.35 | 0.00 | 0.00 | 1.00 |
| Building Class: C (1/0) | 0.09 | 0.28 | 0.00 | 0.00 | 1.00 |
| Tenant Industry: Health (1/0) | 0.06 | 0.24 | 0.00 | 0.00 | 1.00 |
| Tenant Industry: Finance (1/0) | 0.03 | 0.16 | 0.00 | 0.00 | 1.00 |
| Tenant Industry: Legal (1/0) | 0.01 | 0.09 | 0.00 | 0.00 | 1.00 |
| Tenant Industry: Software (1/0) | 0.01 | 0.09 | 0.00 | 0.00 | 1.00 |
| Tenant Industry: Commercial (1/0) | 0.01 | 0.10 | 0.00 | 0.00 | 1.00 |
| Tenant Industry: Media (1/0) | 0.02 | 0.14 | 0.00 | 0.00 | 1.00 |
| Tenant Industry: Real Estate (1/0) | 0.01 | 0.12 | 0.00 | 0.00 | 1.00 |
| Tenant Industry: Insurance (1/0) | 0.02 | 0.13 | 0.00 | 0.00 | 1.00 |
| Tenant Industry: Non-Profit (1/0) | 0.02 | 0.12 | 0.00 | 0.00 | 1.00 |
| Tenant Industry: Unknown (1/0) | 0.31 | 0.46 | 0.00 | 0.00 | 1.00 |
| Unique Properties | 3,476 | | | | |
| N | 10,872 | | | | |

*Note:* This table reports summary statistics for industrial property lease contracts in the full sample. Initial rent and TI allowance are expressed as unit rent per square foot. Annual growth refers to the constant yearly rate at which initial rent would need to increase to reach the final rent by the end of the lease term. It is calculated as the compound annual growth rate.

Table A3: **Summary Statistics (Retail Property)**

| | Mean | SD | Min | Median | Max |
|---|---|---|---|---|---|
| Lease Term (years) | 4.17 | 2.22 | 1.00 | 4.00 | 30.00 |
| Effective Rent ($/sqft/year) | 11.50 | 7.63 | 1.58 | 9.72 | 77.38 |
| Lease Size (sqft) | 34,630.26 | 68,746.19 | 638.00 | 11,902.00 | 1.00e+06 |
| Initial Rent ($/sqft/year) | 11.25 | 7.36 | 1.65 | 9.60 | 75.00 |
| Annual Escalation (%) | 1.92 | 1.54 | 0.00 | 2.96 | 13.90 |
| Free Rent (months) | 0.99 | 1.58 | 0.00 | 0.00 | 30.00 |
| TI Allowance ($/sqft) | 1.68 | 7.91 | 0.00 | 0.00 | 265.00 |
| Concession Ratio (%) | 1.95 | 2.78 | 0.00 | 0.00 | 17.26 |
| Present Value ($/sqft) | 544.62 | 551.07 | 23.38 | 402.71 | 14,872.14 |
| Sublease (1/0) | 0.04 | 0.20 | 0.00 | 0.00 | 1.00 |
| Lease: Gross (1/0) | 0.27 | 0.45 | 0.00 | 0.00 | 1.00 |
| Lease: Modified Gross (1/0) | 0.15 | 0.35 | 0.00 | 0.00 | 1.00 |
| Lease: NNN (1/0) | 0.58 | 0.49 | 0.00 | 1.00 | 1.00 |
| Transaction: New Lease (1/0) | 0.57 | 0.49 | 0.00 | 1.00 | 1.00 |
| Transaction: Renewal (1/0) | 0.22 | 0.41 | 0.00 | 0.00 | 1.00 |
| Transaction: Extension (1/0) | 0.04 | 0.19 | 0.00 | 0.00 | 1.00 |
| Renovation-adjusted Age (years) | 26.69 | 14.63 | 0.00 | 27.00 | 120.00 |
| Building Class: A (1/0) | 0.15 | 0.36 | 0.00 | 0.00 | 1.00 |
| Building Class: B (1/0) | 0.59 | 0.49 | 0.00 | 1.00 | 1.00 |
| Building Class: C (1/0) | 0.25 | 0.43 | 0.00 | 0.00 | 1.00 |
| Tenant Industry: Health (1/0) | 0.04 | 0.20 | 0.00 | 0.00 | 1.00 |
| Tenant Industry: Finance (1/0) | 0.01 | 0.08 | 0.00 | 0.00 | 1.00 |
| Tenant Industry: Legal (1/0) | 0.01 | 0.08 | 0.00 | 0.00 | 1.00 |
| Tenant Industry: Software (1/0) | 0.04 | 0.19 | 0.00 | 0.00 | 1.00 |
| Tenant Industry: Commercial (1/0) | 0.01 | 0.11 | 0.00 | 0.00 | 1.00 |
| Tenant Industry: Media (1/0) | 0.03 | 0.18 | 0.00 | 0.00 | 1.00 |
| Tenant Industry: Real Estate (1/0) | 0.01 | 0.11 | 0.00 | 0.00 | 1.00 |
| Tenant Industry: Insurance (1/0) | 0.00 | 0.06 | 0.00 | 0.00 | 1.00 |
| Tenant Industry: Non-Profit (1/0) | 0.01 | 0.11 | 0.00 | 0.00 | 1.00 |
| Tenant Industry: Unknown (1/0) | 0.39 | 0.49 | 0.00 | 0.00 | 1.00 |
| Unique Properties | 18,839 | | | | |
| N | 71,911 | | | | |

*Note:* This table reports summary statistics for retail property lease contracts in the full sample. Initial rent and TI allowance are expressed as unit rent per square foot. Annual growth refers to the constant yearly rate at which initial rent would need to increase to reach the final rent by the end of the lease term. It is calculated as the compound annual growth rate.

Table A4: Regression results by property type

| | (1) Office | (2) Industrial | (3) Retail |
|---|---|---|---|
| Lease Term ($\tau$) | -0.0028 | -0.0126 | 0.0038 |
| | (0.0038) | (0.0091) | (0.0193) |
| Lease Term$^2$ ($\tau^2$) | 0.0027*** | 0.0038** | 0.0019 |
| | (0.0005) | (0.0015) | (0.0023) |
| Lease Term$^3$ ($\tau^3$) | -0.0001*** | -0.0001 | -0.0000 |
| | (0.0000) | (0.0001) | (0.0001) |
| Interest Rate $\times$ Lease Term ($r\tau$) | 0.2894** | 0.2379 | 1.5598** |
| | (0.1248) | (0.3115) | (0.6600) |
| Interest Rate $\times$ Lease Term$^2$ ($r\tau^2$) | -0.0533*** | -0.0341 | -0.1469* |
| | (0.0172) | (0.0529) | (0.0786) |
| Interest Rate $\times$ Lease Term$^3$ ($r\tau^3$) | 0.0014** | 0.0001 | 0.0027 |
| | (0.0007) | (0.0025) | (0.0026) |
| Annual Escalation (%) | 2.7469*** | 3.1429*** | 2.8575*** |
| | (0.0750) | (0.1169) | (0.3259) |
| Renovation-adjusted Age | -0.0013*** | -0.0020*** | -0.0023*** |
| | (0.0001) | (0.0005) | (0.0007) |
| Concession Ratio (%) | -1.3027*** | -1.4560*** | -1.8333*** |
| | (0.0212) | (0.0514) | (0.1525) |
| Log Floor Area (log sqft) | -0.0148*** | -0.0718*** | -0.1595*** |
| | (0.0011) | (0.0034) | (0.0072) |
| 1(Lease: Renewal) | 0.0178*** | 0.0359*** | 0.0389*** |
| | (0.0018) | (0.0038) | (0.0144) |
| 1(Tenant: Energy) | 0.0087 | -0.0280 | -0.1531* |
| | (0.0067) | (0.0200) | (0.0874) |
| 1(Tenant: Retail) | 0.0457*** | -0.0512*** | -0.0939*** |
| | (0.0153) | (0.0189) | (0.0284) |
| Time Fixed Effects ($\alpha_t$) | Yes | Yes | Yes |
| Property Fixed Effects ($\alpha_i$) | Yes | Yes | Yes |
| Observations | 194,025 | 71,911 | 10,872 |
| $R^2$ | 0.352 | 0.650 | 0.301 |

*Notes:* This table reports the estimation results of Equation (7). Robust standard errors are shown in parentheses. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.10$.