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Climate Policy Uncertainty and Housing Prices: Analyzing Bidirectional Transmission Across U.S. Metropolitan Areas

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Abstract

This study examines the relationship between climate policy uncertainty (CPU) and residential housing prices across U.S. metropolitan areas using the U.S. CPU index developed by Gavriilidis in 2021 and monthly S&P CoreLogic Case-Shiller Home Price Indices, covering January 1991 to May 2024. Employing a Fourier-augmented Toda–Yamamoto causality framework that accounts for both abrupt and gradual structural breaks, we document significant *CPU* $\rightarrow$ *housing prices* transmission in multiple metropolitan markets, with bidirectional transmission dynamics emerging in Los Angeles, New York, San Diego, and San Francisco, as well as at the U.S. national level. The results reveal substantial spatial heterogeneity across various market types. Coastal high-exposure markets exhibit strong CPU sensitivity, which may reflect the influence of physical climate risks and regulatory uncertainty; inland growth markets display *housing prices* $\rightarrow$ *CPU* feedback, likely operating through political economy channels; Midwest extreme-weather markets show persistent transmission despite their non-coastal locations; recession-sensitive markets become CPU-responsive following the Great Recession; and insulated markets show no significant transmission. The findings indicate that CPU operates as a priced systematic risk factor requiring integration into housing finance oversight, macroprudential frameworks, and investment strategies. These results have important implications for financial stability monitoring, mortgage credit risk assessment, and climate policy design as markets navigate transition risks in a low-carbon economy.

Keywords: S&P CoreLogic Case-Shiller Home Price Indices; climate policy uncertainty; Fourier-augmented Toda-Yamamoto causality framework; bidirectional transmission; abrupt and gradual structural breaks; U.S. metropolitan areas

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1. Introduction

Climate change has intensified both physical and transition risks across urban areas, fundamentally reshaping expectations in asset markets. As urban environments confront mounting climate-related risks, ranging from physical hazards such as intensifying flooding, extreme heat events, and sea-level rise to transition risks arising from regulatory overhauls and decarbonization imperatives, the mechanisms through which policy uncertainty transmits into asset pricing have become an urgent empirical and policy priority. This paper examines how climate policy uncertainty (CPU) influences metropolitan-level residential housing prices in the U.S., with a focus on structural breaks, regional heterogeneity, and bidirectional feedback dynamics.

There is a growing awareness of CPU among academics, policymakers, investors, and the public sphere (Adler and Hadorn 2014; Giglio et al. 2021; Painter 2011; Yohe and Oppenheimer 2011). This uncertainty stems from the complexities and ambiguities surrounding climate science, which continue to fuel debates among climate skeptics who argue that the scientific consensus is not as firm as it is often presented. The scientific consensus on human-induced climate change has grown stronger, with the Intergovernmental Panel on Climate Change (IPCC 2023) documenting a marked acceleration in the frequency and intensity of extreme weather events, phenomena that were once anticipated to occur every fifty years are now projected to recur approximately every decade, while the attribution of these events to human influence has strengthened over time. Landmark events such as the catastrophic flooding across Germany and Belgium in July 2021, the record-breaking heat in the Pacific Northwest, and the persistent wildfire seasons in the Western U.S. have transformed climate risk from a theoretical concern to a tangible, recurring economic shock. According to survey data from Redfin (2022), nearly two-thirds of prospective homebuyers are increasingly cautious about purchasing homes in areas vulnerable to extreme temperatures.

As climate risks become more prevalent, the real estate sector remains particularly vulnerable to their diverse and far-reaching consequences. Historical trends demonstrate market responsiveness to perceived climate threats. During the 1950s and 1960s, the insurance industry's inability to evaluate flood risks prompted the federal government to establish the National Flood Insurance Program (NFIP) for high-risk properties. The NFIP's assumption of a 1% annual flooding probability within 100-year flood zones is increasingly inadequate given the growing frequency and severity of climate events (Botts 2021).[1] Although the U.S. has yet to implement a nationwide carbon tax, the potential for future climate policy shifts introduces uncertainty that increases investment risk for carbon-intensive capital (Fried et al. 2021), which may have indirect effects for regional economic activity and metropolitan housing markets.[2]

Real estate is a significant asset class pivotal to household wealth and economic stability, with primary residences accounting for a substantial portion of individual assets. Baldauf et al. (2020) note that real estate's durability exposes it to long-run climate risks, with heterogeneous beliefs about these risks reflected in housing prices. Aladangady et al. (2023) report that nearly two-thirds of homeowners hold home-secured debt, with approximately 66.1% of U.S. households owning primary residences compared to only 54.3% possessing retirement accounts. This illustrates the critical role of real estate in household wealth, particularly as collateral for debt. The relationship between housing prices and macroeconomic activity is well established; movements in housing prices frequently serve as leading indicators of business cycle dynamics, making timely insights into housing market trajectories crucial for policymakers and investors.

Real estate's vulnerability to climate risk operates through multiple channels. First, physical hazards directly erode property values in exposed locations, raise insurance costs, and reduce access to the mortgage market (Duan and Li 2024; Issler et al. 2024; Shi and Varuzzo 2020). Second, transition risks, the economic consequences of climate policies such as carbon pricing, building energy mandates, or fossil fuel regulations, introduce a distinct and potentially more pervasive layer of uncertainty. Unlike discrete, localized shocks associated with individual weather events, CPU pervades markets as a systemic force, reshaping investor expectations, discount rates, and buyer behavior across entire metropolitan areas. Third, demographic shifts induced by climate risk, particularly migra-

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tion away from high-risk coastal communities, alter local demand fundamentals in ways that interact with policy dynamics.

Despite growing research on climate risk and real estate, three critical gaps persist. First, existing empirical literature disproportionately examines the impact of specific, discrete climate events, such as hurricanes, floods, or wildfires, on local housing values, while the broader and more continuous influence of CPU as a price transmission channel has received insufficient attention. Second, prior studies overwhelmingly rely on either micro-level data from specific markets or macro-level national aggregates, obscuring the cross-sectional heterogeneity in how different U.S. metropolitan areas respond to climate policy signals. Third, existing work typically models housing prices as a unidirectional outcome of climate risk, overlooking feedback mechanisms whereby housing market dynamics themselves influence climate policy expectations, a bidirectional relationship with important implications for economic modeling and policy design.

This paper makes four distinct contributions to the literature. First, we treat the CPU not merely as a covariate but as a price transmission channel, empirically investigating how uncertainty about climate policy propagates into residential housing price dynamics at the metropolitan level. Second, using monthly S&P CoreLogic Case-Shiller Home Price Indices, we provide a systematic metropolitan-level analysis of CPU's impact on housing prices across major U.S. markets. Third, we employ an econometric framework designed to account for both abrupt and gradual structural breaks in the data, improving on prior studies that typically ignore gradual shifts driven by the slow evolution of regulatory expectations and investor sentiment and instead focus only on discrete breaks. Fourth, by testing bidirectional transmission between the CPU and metropolitan-level housing prices, we examine whether housing market signals feed back into policy uncertainty itself.

Using the U.S. CPU index, constructed from textual analysis of terms associated with climate risk, our results indicate that climate-related uncertainty has a statistically significant impact on residential real estate values, with effects varying meaningfully by metropolitan area, evidence that regional heterogeneity in climate exposure, political economy, and local housing market structure all shape the transmission mechanism. Moreover, we document bidirectional transmission in major markets, where housing dynamics feed back into the CPU itself. The findings carry direct relevance for investors, homeowners, mortgage lenders, insurance companies, and policymakers grappling with the financial stability implications of climate change. By demonstrating that CPU is increasingly embedded in housing market prices, beyond the effects of individual physical events, this study underscores the systemic nature of climate risk in real estate and the need for both improved regulatory transparency and climate risk disclosure frameworks.

2. Literature Review

A substantial literature documents the capitalization of physical climate risks into real estate prices. Our research contributes to the broader literature on real estate price dynamics (Chambers et al. 2021; Piazzesi et al. 2007) as well as the growing body of work examining the impact of climate risk on asset valuations (Bolton and Kacperczyk 2021; Choi et al. 2020; Duan et al. 2025). The consensus that emerges from this literature is nuanced: physical climate risks do affect housing prices, but the magnitude, timing, and geographic scope of these effects vary considerably, and significant mispricing of risk persists across many housing markets.

2.1. Physical Climate Risk and Housing Markets

Research on sea-level rise and coastal flooding documents significant valuation effects. Murfin and Spiegel (2020) leverage variation in expected time-to-inundation due to vertical land motion to identify null effects, suggesting that anticipated flood risks are not yet fully reflected in coastal home prices. By contrast, Fang et al. (2023) demonstrate that Hurricane Sandy generated significant price discounts for flood-exposed properties in Miami-Dade County, a nonlocal shock indicating that salient events update buyer beliefs in geographically distant markets. Yi and Choi (2020) show that the Great Iowa Flood of 2008 led to short-term price discounts in Des Moines for inundated properties, while non-inundated floodplain homes experienced post-flood price rebounds, indicating updated risk perceptions. Heberger et al. (2009) project that California coastal communities face additional challenges from sea-level rise, threatening critical infrastructure and transport networks.

Wildfire risk has received increasing attention following devastating fire seasons in California and other states. Mueller et al. (2009) document that homes in wildfire-prone areas experience decreased demand as buyers internalize the probability of future disasters and rising insurance costs. McCoy and Walsh (2018) demonstrate that wildfire risk is capitalized into housing prices, mediated by proximity to past burn scars and local risk disclosure practices. Donadelli et al. (2020) find that increased tornado activity leads to declines in local housing prices and affects stock returns, showing that natural hazard risk can influence real estate and broader asset markets. Dell et al. (2012), Deschênes and Greenstone (2007), and Donadelli et al. (2021) show that increased temperatures can negatively affect economic growth, suggesting that climate-driven macroeconomic stress, particularly during periods of heightened uncertainty, may translate into broader pressure on asset markets, including housing, whose values depend on local economic fundamentals.

Contat et al. (2024) survey comprehensive literature on climate and real estate, noting that while the price effects of physical climate hazards are well-documented for discrete events, the longer-run and more diffuse effects of climate policy developments on housing market dynamics represent a frontier area where empirical evidence remains sparse. This gap motivates the central empirical contribution of the present paper: treating CPU, rather than specific climate events, as the primary explanatory variable.

2.2. CPU as a Price Transmission Channel

While the literature has extensively documented how physical climate events affect housing prices, far less attention has been paid to the role of regulatory and policy uncertainty as an independent transmission channel. This distinction is conceptually important: physical events are discrete and localized, while the CPU is continuous, systemic, and operates across all markets simultaneously, irrespective of their direct physical exposure. Understanding CPU as a transmission channel requires integrating insights from the broader economic policy uncertainty literature and applying them to the specific institutional context of U.S. housing markets.

Baker et al. (2016) established the foundational framework for measuring economic policy uncertainty through textual analysis of news content. Gavriilidis (2021) adapted this methodology to construct the U.S. CPU index, specifically systematically quantifying the frequency with which major newspapers reference climate change in conjunction with policy uncertainty. This index has since been employed across multiple asset classes: Bouri et al. (2022) demonstrate that CPU significantly influences the prices of green and brown energy equities; Lv and Li (2023) find that CPU drives Chinese stock market volatility across different sectors; and He and Zhang (2022) show that CPU predicts oil industry returns. Faccini et al. (2023) show that only climate-policy news risk is priced in U.S. stocks, particularly after 2012, indicating that investors mainly hedge transition risk rather than physical climate risk.

Cho et al. (2024) examine how CPU influences real estate market volatility across sectors and regions. They find a significant impact of CPU on sectors with high energy demand and emissions, including industrial and residential sectors, with long-term sensitivity noted in coastal regions prone to climate risks. While their analysis reveals nuanced sectoral differences, it stops short of examining metropolitan-level price levels, structural breaks, or feedback dynamics. Duan and Li (2024) document that climate risk is increasingly reflected in mortgage market conditions, including loan rejection rates and interest rate spreads, providing indirect evidence of CPU transmission through credit market channels.

The *CPU* $\rightarrow$ *housing price* transmission mechanism operates through several channels. First, the investment channel arises as rational economic agents delay or scale back projects when regulatory outcomes remain uncertain. In housing markets, CPU increases the option value of waiting: prospective buyers, developers, and investors may postpone commitments until regulatory trajectories become clearer, thereby dampening demand and exerting downward pressure on housing prices. Next, the insurance and mortgage channel operates through financial intermediaries, as lenders tighten credit conditions and insurers adjust coverage in climate-exposed markets when CPU increases. As insurers reprice climate risk in response to policy signals, premium increases and coverage withdrawals raise the effective cost of homeownership in exposed areas, reducing buyer demand and suppressing equilibrium prices (Issler et al. 2024). Finally, the expectations channel reflects forward-looking behavior, whereby CPU shifts market expectations as buyers discount future property values in response to anticipated retrofit requirements, future regulatory burdens, including potential carbon taxes, energy efficiency mandates, and zoning changes.[3] These mechanisms are not mutually exclusive; they are likely to operate simultaneously and to interact, particularly in metros with high physical exposure and active regulatory environments.

A crucial but underexplored dimension of this transmission is its heterogeneity across metropolitan areas. The degree to which CPU transmits into local housing prices will depend on local factors, including physical climate exposure, the composition of the housing stock, such as energy efficiency levels, age, and construction type, local political economy and climate regulation history, the degree of insurance market stress, and the demographics of local buyers and investors. Contat et al. (2024) note that the capitalization of climate risk varies substantially across markets, with disclosure laws and climate beliefs playing a moderating role. Our empirical framework is designed to explicitly capture this cross-metropolitan heterogeneity.

2.3. Structural Breaks, Gradual Regime Shifts, and Feedback Dynamics

A defining methodological feature of this study is the explicit treatment of structural breaks, both abrupt and gradual, in the relationship between CPU and metropolitan-level housing prices. Most empirical studies in this domain model climate risk effects within a stationary, time-invariant framework, implicitly assuming that the relationship between policy uncertainty and housing prices is stable over time. This assumption is increasingly untenable in a world characterized by accelerating climate policy developments, evolving scientific consensus, and episodic regulatory shocks.

Abrupt structural breaks may arise from discrete events: landmark climate legislation announcements, withdrawal from international climate agreements, major IPCC report releases, or catastrophic climate events that fundamentally shift public and investor expectations. These breaks are relatively tractable econometrically, addressed via event-study designs and dummy variable inclusions. However, gradual structural changes, the slow drift in regulatory expectations, incremental repricing of climate risk by institutional lenders and insurers, and progressive updating of buyer beliefs, are substantially harder to detect and have been largely ignored.

This study advances literature in two main ways. First, it relaxes the common assumption of parameter stability by explicitly allowing for both abrupt policy shifts and gradual structural evolution. The empirical design integrates the Toda and Yamamoto (1995, hereafter TY) framework with a flexible Fourier specification that allows a time-varying intercept to capture both discrete breaks and smooth transitions without pre-specified break dates.[4] This methodological innovation more accurately captures the evolving *CPU* $\rightarrow$ *housing prices* transmission relationship, which is particularly important given that gradual breaks may dominate structural change in housing markets, where price adjustments are slow due to transaction costs, information frictions, and long-term mortgage commitments.

Second, the analysis moves beyond national aggregates by providing metropolitan-level evidence on transmission directionality, documenting not only *CPU* $\rightarrow$ *housing prices* transmission but also *housing prices* $\rightarrow$ *CPU* feedback in select metropolitan areas. While the standard assumption is unidirectional causality from policy uncertainty to asset prices, we posit a theoretically plausible feedback mechanism: sustained declines in housing values in climate-exposed metros could generate political pressure for regulatory responses, shift public opinion on climate policy, or signal financial systemic risks to policymakers. This metropolitan-level perspective highlights meaningful spatial heterogeneity and constitutes a novel and policy-relevant contribution.

2.4. Climate Risk Mispricing, Demographic Responses, and Systemic Implications

A central concern is the systematic mispricing of climate risk in housing markets, with profound implications for household wealth, financial stability, and public finance. Gourevitch et al. (2023) estimate that U.S. residential properties exposed to flood risk are overvalued by between $121 billion and $237 billion, with overvaluation concentrated in states lacking flood risk disclosure laws and communities with lower climate concern, a pattern directly implicating information asymmetry and belief heterogeneity as mispricing drivers. Bretz (2017) projects that nearly 1.9 million U.S. homes, valued over $916 billion, could face chronic flooding by 2100, with disproportionate consequences for lower-income households concentrated in high-risk coastal metros, including Miami, New York, Tampa, Boston, and Houston.

The theory of belief heterogeneity within asset markets is rooted in the seminal contributions of Miller (1977) and Harrison and Kreps (1978), who demonstrated how divergent investor beliefs can lead to speculative behavior and asset mispricing. This mispricing is exacerbated by information asymmetry and heterogeneous distribution of climate risk beliefs across buyers and communities (Baldauf et al. 2020; Battiston et al. 2021). Warren-Myers and Hurlimann (2022) emphasize that climate risk perceptions, alongside objective hazard measures, play key roles in shaping real estate market responses. Keller et al. (2020) demonstrate that media framing of climate risk can amplify perceived vulnerability and accelerate price adjustments in high-risk areas. This media-belief-price nexus is particularly relevant to CPU, since policy uncertainty is itself media-mediated, transmitted to market participants largely through news coverage and public discourse.

At the macro level, climate risk mispricing poses systemic risks to the broader financial system. A sudden downward revaluation of climate-exposed properties, triggered by a major policy shock crystallizing previously diffuse CPU, could generate cascading effects through mortgage markets, bank balance sheets, and local government finances dependent on property tax revenues. Demographic responses add further complexity to metropolitan-level housing dynamics. As households relocate from high-risk areas, particularly coastal communities facing sea-level rise, toward more climate-resilient interior metros, local demand fundamentals shift in ways that interact with CPU. Shi and Varuzzo (2020) document population decline and eroding tax bases in climate-vulnerable coastal communities, while climate-resilient cities may experience demand-driven price appreciation.

In synthesis, literature converges on several important observations. Physical climate risk clearly affects housing prices, but significant mispricing persists. CPU constitutes a distinct and underexplored transmission channel through which policy ambiguity propagates into real estate markets, operating through investment, insurance, and expectations mechanisms. The heterogeneity of these effects across metropolitan areas, the presence of structural breaks in the transmission relationship, and the possibility of bidirectional feedback dynamics have not been systematically investigated. The remainder of the paper is structured as follows: Section 3 describes the proposed empirical methodology. Section 4 outlines the sources of the data. Section 5 presents the results and discussion. Finally, Section 6 provides the conclusion, and Section 7 offers the policy implications.

3. Empirical Methodology

This study analyzes price transmission dynamics between CPU and housing prices using econometric methods capable of capturing both abrupt and gradual structural changes (smooth breaks), ensuring robustness to external shocks and long-run time-series data. The analysis investigates level-based relationships in a bidirectional framework, assessing whether historical CPU values predict future housing prices and vice versa, without imposing a priori assumptions about Granger causality direction. Evidence of bidirectional causality would indicate a feedback transmission mechanism whereby each variable contributes to the other's dynamic evolution.

The *CPU* → *housing prices* channel reflects the role of CPU as a state variable shaping forward-looking property valuations. Increases in uncertainty regarding the timing, stringency, or scope of climate regulation may lead households, developers, and lenders to revise expectations about costs, insurability, retrofit requirements, and long-run rental income, thereby affecting housing prices. Conversely, the *housing prices* → *CPU* channel is economically plausible because housing markets are macroeconomically significant and politically salient. Large fluctuations in housing prices and affordability influence household wealth, local fiscal capacity, and distributional perceptions of climate policy, potentially intensifying political debate and policy bargaining, and thus elevating measured CPU.

Structural shifts are critical for accurately modeling the *CPU* → *housing price* relationship, as CPU data reflects both abrupt and gradual changes driven by international climate agreements (e.g., the Kyoto Protocol and the Paris Agreement), climate-related disasters, political transitions, and new regulatory initiatives. These shifts signal turning points in how climate risk is perceived by the public, media, and policymakers. Incorporating such nonlinear dynamics improves forecast accuracy by reflecting the reality that investor and homeowner responses to climate risk are often triggered by threshold events, such as abrupt property value declines or spikes in market volatility, rather than by smooth, gradual adjustments. Regional heterogeneity matters, as structural breaks vary significantly across metropolitan areas, with coastal versus inland and high-growth versus recession-sensitive markets displaying distinct sensitivities. Ignoring these break patterns produces biased estimates, whereas accurately incorporating them reflects real-world market disruptions and offers more reliable, context-specific guidance for policymakers and investors.

Testing for Price Transmission

To explore how prices transmit across markets, we adopt a Fourier-augmented transmission framework following Nazlioglu et al. (2016, 2019) and Gormus et al. (2018). Their method extends the TY approach, which suggests increasing the lag order p in a VAR by the maximum order of integration d found among the variables. Consequently, the model takes the form $\text{VAR}_{(p+d)}$ in levels of y_t. The lag-augmented VAR model can thus be expressed as:

$$y_t = A + B_1 y_{t-1} + \ldots + B_{p+d} y_{t-(p+d)} + e_t, \quad (1)$$

where y_t is the vector of endogenous variables, A is a constant vector, B = (B_1, . . ., B_p)′ represents the parameter matrices, e_t is the error term, and p is the original number of lags. To test whether there is no Granger causality (i.e., price spillover) from one variable to another, we examine the null hypothesis (H_0: B_1 = . . . = B_p = 0) by using the standard Wald test, which follows a chi-square distribution with p degrees of freedom. In the TY procedure, the non-causality null refers specifically to zero restrictions on the first p parameters of the variable under consideration, and the associated Wald statistic retains its usual chi-square distribution with p degrees of freedom.

A challenge with the classical Wald test arises when ignoring structural breaks in the data, as highlighted by Ventosa-Santaulària and Vera-Valdés (2008). Such unaccounted breaks can lead to over-rejection of the null and distort the size of the test (Enders and Holt 2014). Consequently, standard Granger-causality findings may be questionable if structural breaks exist or have not been adequately modeled. Moreover, in a VAR context, detecting or dealing with breaks can be difficult since the breakpoints can arise from dynamic interactions among variables (Enders and Jones 2016).

To address this, Nazlioglu et al. (2016, 2019) and Gormus et al. (2018) draw on the Flexible Fourier Form concept by Gallant (1981) to incorporate structural shifts in the constant term A, denoted as A(t). The following Fourier approximation captures these changes as a smooth process at an unknown date:

$$A(t) \cong A_0 + A_1 \sin\left(\frac{2\pi kt}{T}\right) + A_2 \cos\left(\frac{2\pi kt}{T}\right), \quad (2)$$

where $A(t)$ is time-dependent to account for any structural shifts in y_t, k is the integer frequency, and A_1 and A_2 capture the amplitude and phase shift, respectively. Substituting Equation (2) into the lag-augmented VAR gives

$$y_t = A_0 + A_1 \sin\left(\frac{2\pi kt}{T}\right) + A_2 \cos\left(\frac{2\pi kt}{T}\right) + B_1 y_{t-1} + \ldots + B_{p+d} y_{t-(p+d)} + u_t, \quad (3)$$

and the conventional TY testing procedure can then be applied to examine price transmission in the presence of potential structural shifts.[5]

4. Data

We obtained monthly data for the S&P CoreLogic Case-Shiller U.S. National Home Price Index from January 1991 to May 2024, along with 19 metropolitan-level indices covering Atlanta, Boston, Charlotte, Chicago, Cleveland, Denver, Detroit, Las Vegas, Los Angeles, Miami, Minneapolis, New York, Phoenix, Portland, San Diego, San Francisco, Seattle, Tampa, and Washington, D.C.[6] The repeat-sales methodology used to construct those indices measures real estate price changes by tracking individual properties' sale prices over time, controlling for quality differences using value-weighted sale pairs. Monthly indices are calculated using three-month moving averages to mitigate reporting delays and maintain adequate sample sizes for reliable measurement of price changes. Although the sample is limited to the 19 major metropolitan areas included in the 20-City Composite Home Price Index, these markets account for a substantial share of U.S. housing market value while providing theoretically relevant variation in climate exposure, geographic diversity, regulatory stringency, supply elasticity, and economic structure, thereby enabling the identification of spatial heterogeneity in the transmission dynamics between CPI and housing prices.

We utilize the CPU index developed by Gavriilidis (2021), constructed from textual analysis of eight major U.S. newspapers, which quantifies the policy uncertainty that drives the expectations channel by capturing shifts in regulatory ambiguity surrounding climate policy. The index identifies articles that simultaneously contain (i) the terms *uncertainty* or *uncertain*, including variants such as *uncertainties*, (ii) climate-related terms (e.g., *carbon dioxide*, *climate change*, *greenhouse gas emissions*, *renewable energy*, *environmental*, etc.), and (iii) policy-related terms (e.g., *regulation*, *legislation*, *White House*, *Congress*, *EPA*, *law*, *policy*, and related variants). The search spans articles published from April 1987 onward in the following newspapers: *The Boston Globe*, *Chicago Tribune*, *Los Angeles Times*, *Miami Herald*, *New York Times*, *Tampa Bay Times*, *USA Today*, and *The Wall Street Journal*. For each newspaper, the monthly proportion of relevant articles is computed relative to the total number of articles, standardized to have a unit standard deviation, and then averaged across newspapers. The resulting index is normalized to a mean of 100 over the period April 1987 to August 2022.

To isolate the CPU's distinct role from broader macroeconomic uncertainty, we also include the Economic Policy Uncertainty (EPU) index of Baker et al. (2016). The insurance and mortgage channel is proxied by 30-year fixed-rate mortgage rates, which reflect lenders' repricing of climate-related collateral risk and credit market tightening. The investment channel operates through macroeconomic fundamentals that shape housing demand and construction activity. These dynamics are captured by several control variables. Energy prices, measured by West Texas Intermediate (WTI) crude oil prices and residential natural gas prices, serve as proxies for energy transition costs that affect both operating expenses and regulatory pressure on real estate development. Additional controls, such as inflation, unemployment rates, and real disposable income per capita, jointly influence households' capacity to absorb climate policy shocks and their willingness to invest in long-lived, immobile assets such as housing under regulatory uncertainty.[7]

Table 1 presents the descriptive statistics. Housing price indices vary substantially across metropolitan areas. Housing price indices vary substantially across metropolitan areas. Los Angeles and San Francisco rank highest in average index values, at 194.30 and 171.01, respectively, while Detroit and Cleveland display the lowest, at 102.70 and 110.05. This heterogeneity reflects substantial differences in cumulative price appreciation between coastal metropolitan areas and post-industrial metros. The standard deviations reflect varying levels of price volatility across different metropolitan areas. San Diego, with a high standard deviation of 95.36, shows considerable variation in housing prices, reflecting market instability or significant price changes over time. Cleveland, with a relatively low standard deviation of 25.59, suggests a more stable market compared to metros with higher price variability.

Furthermore, skewness and kurtosis values suggest that many metropolitan areas have non-normal price distributions. Charlotte has a skewness of 1.58 and a kurtosis of 5.17, indicating a positively skewed distribution, with most periods showing moderate price growth and occasional rapid appreciation. Washington, D.C., with a skewness of 0.13 and a kurtosis of 1.98, exhibits a relatively symmetric distribution of index values, indicating that price changes have been relatively stable, with fewer extreme movements. In contrast, some metropolitan areas, such as Miami, exhibit greater volatility, as reflected in higher standard deviation and kurtosis, indicating more frequent extreme price movements. Other metropolitan areas, including Cleveland and Detroit, display lower volatility and more stable market conditions, as evidenced by lower standard deviation and kurtosis. The Jarque–Bera (JB) test further indicates that most metropolitan indices, including the national index, deviate significantly from normality, reflecting asymmetric price movements and extreme volatility driven by market dynamics, policy shifts, and local economic conditions. EPU exhibits an extremely high JB statistic of 445.62, indicating a strong departure from normality and the presence of extreme observations, likely reflecting shifts in policy or economic uncertainty affecting the real estate market.

Table 1. Descriptive Statistics.

Variables	Mean	S.D.	Min	Max	Kurtosis	Skewness	JB
Atlanta	120.82	41.54	69.32	246.33	4.66	1.35	168.61 ***
Boston	157.26	69.07	63.56	332.38	2.91	0.56	21.25 ***
Charlotte	127.47	47.59	72.96	277.64	5.17	1.58	244.38 ***
Chicago	125.25	32.99	70.84	205.54	2.36	0.19	9.40 ***
Cleveland	110.05	25.59	68.81	190.74	4.44	1.10	115.90 ***
Denver	144.59	71.06	48.94	325.9	3.34	0.98	66.32 ***
Detroit	102.70	31.15	58.13	186.28	2.98	0.67	29.82 ***
Las Vegas	146.07	61.63	81.09	296.45	2.59	0.87	53.68 ***
Los Angeles	194.30	98.63	73.84	437.30	2.57	0.61	27.61 ***
Miami	180.43	91.27	77.46	437.99	3.52	1.01	72.71 ***
Minneapolis	134.52	46.89	64.29	237.92	2.45	0.36	13.65 ***
New York	159.44	60.60	73.05	308.77	2.33	0.16	9.13 ***
Phoenix	146.68	70.88	64.51	338.91	3.55	1.11	88.03 ***
Portland	157.50	74.42	56.78	337.43	2.89	0.83	46.39 ***
San Diego	184.74	95.36	71.39	435.92	3.13	0.81	44.08 ***
San Francisco	171.01	86.70	66.63	383.64	2.49	0.63	30.54 ***
Seattle	163.59	87.64	65.13	401.52	3.45	1.09	82.66 ***
Tampa	164.60	79.12	80.34	386.00	4.11	1.24	124.06 ***
Washington, D.C.	177.23	68.86	87.92	324.25	1.98	0.13	18.63 ***
USA	153.71	63.31	75.57	320.41	3.22	0.82	45.83 ***
EPU	115.42	41.76	57.00	350.00	7.07	1.59	445.62 ***
CPU	108.63	61.64	28.16	411.29	5.56	1.57	274.46 ***
Oil	51.49	29.42	11.35	133.88	2.09	0.47	28.38 ***
Gas	11.25	4.05	5.50	25.34	3.10	0.69	31.84 ***
Mortgage	5.87	1.77	2.65	9.62	1.92	0.07	19.77 ***
Inflation	2.62	1.59	−2.10	9.06	6.26	1.09	257.50 ***
Unemployment	5.74	1.78	3.40	14.80	4.85	1.20	153.51 ***
Income	39,284.33	6486.30	28,593.00	61,509.00	2.39	0.17	8.26 **

Notes: The table provides a summary of descriptive statistics of 401 observations. JB represents the Jarque and Bera (1987) goodness-of-fit test. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

The results of the Augmented Dickey–Fuller (ADF) and Phillips–Perron (PP) tests provided in Table 2 reveal that all housing price indices exhibit non-stationary behavior, suggesting evidence of structural breaks within the dataset. In contrast, several macroeconomic variables exhibit evidence of stationarity. Specifically, the EPU index, inflation, and unemployment rates are found to be stationary at the 5% level or better. The CPU index shows mixed results, non-stationary under the ADF test but stationary under the PP test, suggesting potential structural breaks. Variables such as oil prices, gas prices, mortgage rates, and income fail to reject the unit root null hypothesis under most specifications, indicating non-stationarity.

Table 2. Unit Root and F-trig Tests.

Variables	ADF	Probability	PP	Probability	F-Trig
Atlanta	0.9107	0.9956	2.3608	1.0000	131.586 ***
Boston	1.5289	0.9994	2.4412	1.0000	106.625 ***
Charlotte	2.1990	1.0000	3.9375	1.0000	80.406 ***
Chicago	−0.2291	0.9318	0.2301	0.9742	164.464 ***
Cleveland	1.6769	0.9996	2.6955	1.0000	139.856 ***
Denver	1.3694	0.9989	1.9282	0.9999	113.370 ***
Detroit	0.1201	0.9669	0.7742	0.9935	297.540 ***
Las Vegas	−0.8833	0.7931	−0.1143	0.9457	239.044 ***
Los Angeles	0.0261	0.9594	1.0900	0.9974	121.619 ***
Miami	−0.7139	0.8406	1.0535	0.9971	124.979 ***
Minneapolis	−0.1334	0.9435	0.3987	0.9827	182.682 ***
New York	0.8779	0.9952	1.1433	0.9978	117.855 ***
Phoenix	−0.6781	0.8494	0.2065	0.9728	135.891 ***
Portland	0.0557	0.9619	1.1032	0.9975	132.275 ***
San Diego	0.6680	0.9914	1.3614	0.9989	133.257 ***
San Francisco	−0.3080	0.9208	0.4289	0.9840	132.305 ***
Seattle	1.2944	0.9987	1.6550	0.9996	121.498 ***
Tampa	−0.3083	0.9208	1.2206	0.9983	129.868 ***
Washington, D.C.	−0.7450	0.8326	0.3420	0.9802	153.078 ***
USA	0.9261	0.9958	2.0811	0.9999	103.457 ***
EPU	−3.6066 ***	0.0060	−5.8436 ***	0.0000	64.667 ***
CPU	−1.6585	0.4517	−6.9802 ***	0.0000	117.897 ***
Oil	−2.4739	0.1227	−1.6760	0.4428	265.535 ***
Gas	−1.2271	0.6638	−2.9182 **	0.0441	82.383 ***
Mortgage	−2.1475	0.2263	−2.0692	0.2575	459.138 ***
Inflation	−3.5096 ***	0.0082	−3.7168 ***	0.0042	53.593 ***
Unemployment	−3.1948 **	0.0210	−2.9611 **	0.0396	83.485 ***
Income	−0.5367	0.8808	−0.7254	0.8376	198.367 ***

Notes: The table presents unit-root tests. ADF represents the Augmented Dickey–Fuller, and PP represents the Phillips–Perron unit-root test statistic. In both tests, the null hypothesis is the presence of a unit root. F-trig tests the significance of trigonometric terms in $y_t = d_0 + d_1 \sin\left(\frac{2\pi kt}{T}\right) + d_2 \cos\left(\frac{2\pi kt}{T}\right) + e_t$, for the null of $d_1 = d_2 = 0$ by using $k = 1$ with the usual F-testing procedure. k^* is the Fourier frequency selected by minimizing the sum of squared residuals from OLS estimation of Equation (4) with $k \in [1, 1.1, 1.2, \ldots, 5]$. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

We also test the significance of gradual/smooth structural breaks based on the regression model $y_t = d_0 + d_1 \sin\left(\frac{2\pi kt}{T}\right) + d_2 \cos\left(\frac{2\pi kt}{T}\right) + e_t$ using the F-test, denoted as F-trig, for the null hypothesis of $d_1 = d_2 = 0$. By employing one frequency, the null hypothesis is rejected at 1% for all series, supporting the significance of gradual breaks. Taken together, these results underscore the necessity of adopting an econometric approach that accommodates various forms of structural breaks, which may be induced by economic shocks, regulatory changes, or evolving market conditions.

5. Results and Discussion

To assess whether the 2007–2009 Great Recession altered the *CPU* – *housing prices* relationship, we partition the sample into pre-recession (January 1991–December 2007, Table 3) and full-sample (January 1991–May 2024, Table 4) periods. Both tables report bidirectional transmission tests: the From CPU columns assess whether historical CPU values Granger-cause metropolitan-level housing prices, while the To CPU columns test the reverse direction. The Wald test statistic evaluates the existence of transmission within a binary hypothesis-testing framework, not its magnitude; statistical significance is assessed by rejecting the null hypothesis of no transmission, with the strength of evidence inferred from *p*-values rather than the size of the test statistic. Results reveal significant *CPU* → *housing prices* transmission in several major U.S. metros, while a limited set of metros exhibit *housing prices* → *CPU* feedback, suggesting bidirectional dynamics in select housing markets.

Table 3. Bidirectional Transmission between CPU and Housing Prices (Pre–Great Recession).

Variables	From CPU	*p*-Value	To CPU	*p*-Value
Atlanta	7.4191 *	0.0597	2.5349	0.4690
Boston	0.1889	0.6639	1.4013	0.2365
Charlotte	0.3885	0.9426	9.7262 **	0.0210
Chicago	3.9103 **	0.0480	1.5472	0.2135
Cleveland	0.0398	0.8418	0.8101	0.3681
Denver	1.2546	0.2627	4.1131 **	0.0426
Detroit	0.3818	0.5366	0.1930	0.6605
Las Vegas	0.2045	0.6511	1.9354	0.1642
Los Angeles	5.1528 **	0.0232	7.8660 ***	0.0050
Miami	11.2369 ***	0.0036	1.6209	0.4447
Minneapolis	2.7509 *	0.0972	0.6437	0.4224
New York	0.0056	0.9406	0.0126	0.9105
Phoenix	9.7862 ***	0.0075	5.9102 *	0.0521
Portland	1.7749	0.4117	5.4421 *	0.0658
San Diego	3.3512	0.1872	12.2451 ***	0.0022
San Francisco	10.1655 ***	0.0014	1.8331	0.1758
Seattle	2.0682	0.3555	15.3164 ***	0.0005
Tampa	4.8565	0.3023	6.4342	0.1690
Washington, D.C.	4.9772 **	0.0257	0.2220	0.6375
USA	1.3960	0.2374	2.6299	0.1049
EPU	1.0117	0.3145	3.6838 *	0.0549

Notes: The results are based on the Fourier TY approach with a single frequency, which is based on Equation (3), with one frequency. The maximum lag (p) is set to 12 and the optimal p is determined by the Schwarz information criterion. The p-value is based on the asymptotic chi-square distribution. $VAR_{(p+d)}$ models are estimated with d equal to 1. VAR models include control variables (EPU, oil and gas prices, 30-year mortgage rate, inflation and unemployment rates, and real disposable income per capita). *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

Table 4. Bidirectional Transmission between CPU and Housing Prices (Full Sample).

Variables	From CPU	*p*-Value	To CPU	*p*-Value
Atlanta	0.1768	0.6741	0.9253	0.3361
Boston	1.1454	0.2845	0.0650	0.7987
Charlotte	2.2336	0.3273	6.3850 **	0.0411
Chicago	8.8147 ***	0.0030	2.3586	0.1246
Cleveland	3.2028	0.3614	1.6990	0.6372
Denver	0.0305	0.8613	4.3198 **	0.0377
Detroit	1.2765	0.2586	1.0992	0.2944
Las Vegas	8.3663 **	0.0153	2.9505	0.2287
Los Angeles	5.4809 **	0.0192	6.9002 ***	0.0086
Miami	9.7178 *	0.0836	8.2241	0.1443
Minneapolis	4.9252 *	0.0852	2.2920	0.3179
New York	12.8099 ***	0.0017	4.8370 *	0.0891
Phoenix	13.8102 ***	0.0032	5.1439	0.1616
Portland	6.5647 **	0.0104	7.6677	0.1045
San Diego	3.8919 **	0.0485	4.7613 **	0.0291
San Francisco	4.8433 **	0.0278	3.2230 *	0.0726
Seattle	6.6226 *	0.0850	4.2488	0.2358
Tampa	8.3574 **	0.0153	3.6440	0.1617
Washington, D.C.	1.7846	0.1816	0.1710	0.6793
USA	6.9698 ***	0.0083	4.3182 **	0.0377
EPU	1.2502	0.2635	9.9902 ***	0.0016

Notes: The results are based on the Fourier TY approach with a single frequency, which is based on Equation (3), with one frequency. The maximum lag (p) is set to 12 and the optimal p is determined by the Schwarz information criterion. The p-value is based on the asymptotic chi-square distribution. $\text{VAR}_{(p+d)}$ models are estimated with d equal to 1. VAR models include control variables (EPU, oil and gas prices, 30-year mortgage rate, inflation and unemployment rates, and real disposable income per capita). *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

5.1. Pre–Great Recession Evidence: Establishing Baseline Transmission Patterns

Table 3 reveals two distinct patterns. First, *CPU* $\rightarrow$ *housing prices* transmission is statistically significant at the 5% level or better in six metros, such as Chicago, Los Angeles, Miami, Phoenix, San Francisco, and Washington, D.C., while significance at the 10% level is observed in Atlanta and Minneapolis. This pattern indicates that CPU is heterogeneously priced across locations; rather, it is more relevant in markets where regulatory expectations, development constraints, and long-run climate-related costs plausibly play a larger role in housing valuation. These findings support the view that the CPU acts as a forward-looking state variable, influencing property prices through investor and lender expectations about future costs, insurability, retrofit requirements, and rental income streams.

Second, reverse transmission, *housing prices* $\rightarrow$ *CPU*, appears in Charlotte, Denver, Los Angeles, San Diego, and Seattle at the 5% level or better, and in Phoenix and Portland at the 10% level. Bidirectional transmission is observed in Los Angeles and Phoenix. This asymmetry suggests that housing market conditions feed back into measured CPU primarily when local dynamics are sufficiently salient to shape policy debate and distributional concerns about future regulatory frameworks.

For investors and homeowners in CPU-sensitive metros, uncertainty directly affects expected holding costs and exit values. Developers face regulatory ambiguity regarding building codes, carbon pricing, and zoning restrictions, while lenders incorporate CPU-related tail risks into mortgage pricing and underwriting standards. The feedback channel operates differently in inland growth markets like Charlotte and Denver, where rapid housing price appreciation elevates the political and economic stakes of environmental regulation, intensifying policy debate and measured uncertainty.

5.2. Full-Sample Evidence: Temporal Evolution and Broadening Transmission

Table 4 reports the corresponding results for the full sample, incorporating the Great Recession and subsequent periods, and reveals three key shifts relative to the results in Table 3.

First, *CPU* → *housing prices* transmission becomes more pervasive, extending to metropolitan areas such as Las Vegas, New York, Portland, San Diego, and Tampa, as well as the U.S. national index, at the 5% level or better, and to Seattle at the 10% level. Several metros, such as Chicago, Los Angeles, Miami, Phoenix, Minneapolis, and San Francisco, that were significant prior to the Great Recession continue to exhibit price transmission. This broader pattern is consistent with temporal evolution, where climate policy becomes more economically consequential and frequently debated post-recession, such that uncertainty surrounding its trajectory is increasingly incorporated into housing expectations.

Second, *CPU* → *housing prices* transmission disappears in the full sample for Atlanta and Washington, D.C., despite being significant pre-recession, underscoring that the transmission is both spatially heterogeneous and time-varying, validating our empirical design that allows for structural breaks. These metropolitan areas may have adopted more effective climate risk management strategies post-recession, reducing CPU sensitivity. For example, Atlanta's comprehensive stormwater management and green infrastructure programs, and Washington, D.C.'s RiverSmart and Climate Ready DC initiatives may have reduced physical climate exposure and regulatory uncertainty, buffering housing markets from CPU fluctuations.

Third, *housing prices* → *CPU* transmission remains selective. Charlotte, Denver, Los Angeles, and San Diego maintain this feedback pattern from the pre-recession period. The transmission is also observed in New York and San Francisco at the 10% significance level, and in the U.S. national index at the 5% level. Bidirectional transmission is present in Los Angeles, continuing from the pre-recession period, as well as in New York, San Diego, San Francisco, and at the U.S. national level.

This pattern suggests feedback arises when housing market developments carry broader macroeconomic and political significance, influencing expectations about climate regulation. Historical precedent supports this mechanism, as major climate policy initiatives such as the Clean Power Plan (2015) and the Inflation Reduction Act (2022) were introduced during relatively stable housing market conditions, whereas the 2007–2009 recession redirected policy priorities toward economic stabilization, temporarily delaying climate policy initiatives.[8]

5.3. Classification of Metropolitan Areas by Transmission Patterns

Coastal high-exposure markets, such as Los Angeles, Miami, New York, San Diego, San Francisco, Seattle, and Tampa, exhibit significant *CPU* → *housing prices* transmission in the full sample, reflecting the combined effects of direct physical climate exposure, including sea-level rise, hurricanes, and wildfires, together with elevated regulatory uncertainty surrounding climate adaptation and mitigation policies. Bidirectional transmission observed in Los Angeles, New York, San Diego, and San Francisco suggests that these markets are sufficiently large and politically salient to influence national climate policy discourse. The economic stakes are particularly high in these locations, where housing constitutes a substantial share of household wealth and property values are among the highest in the country. Consequently, climate policy debates can generate heightened uncertainty that is quickly capitalized into housing valuations.

Inland growth markets, such as Charlotte, Denver, Phoenix, and Portland, exhibit heterogeneous patterns. Phoenix shows *CPU* → *housing prices* transmission in both samples, while Portland exhibits it only in the full sample. The *housing prices* → *CPU* feedback appears in all four metropolitan areas during the pre-recession period, although only Charlotte and Denver retain this pattern in the full sample. These metros share characteristics of rapid population growth, active construction cycles, and sensitivity to development regulations. In these contexts, the *housing prices* → *CPU* channel likely operates through political economy dynamics, where rising housing prices elevate the stakes of zoning regulations, sustainability mandates, and infrastructure investments, intensifying policy debate and uncertainty. Phoenix is notable because, despite its inland location, it faces severe climate risks, including water scarcity, extreme heat waves, and prolonged drought, which may explain its persistent sensitivity to CPU and significant pre-recession bidirectional transmission.

Midwest extreme weather markets, such as Chicago and Minneapolis, exhibit *CPU* → *housing prices* transmission in both samples, indicating persistent sensitivity to CPU regardless of macroeconomic conditions. These metros face a range of extreme weather risks, including heat waves, severe thunderstorms and tornadoes, heavy rainfall and flooding, and winter extremes such as blizzards and polar vortex events. Despite inland locations, their persistent CPU sensitivity reflects growing awareness that extreme weather risks drive climate policy responses affecting housing values.

Recession-sensitive markets, such as Las Vegas, show no *CPU* → *housing prices* transmission in the pre-recession sample but exhibit significant transmission in the full sample, suggesting it became CPU-responsive following the Great Recession. Las Vegas is exposed to extreme heat, prolonged drought, flash flooding from monsoon storms, and dust storms associated with desert climate conditions. As a highly speculative housing market, Las Vegas property valuations are particularly sensitive to macroeconomic uncertainty, including CPU, during periods of heightened economic stress.

Insulated markets, such as Atlanta, Boston, Cleveland, Detroit, and Washington, D.C., show no statistically significant transmission in either direction in the full sample. This insulation may reflect the relatively diversified economic structures of these metropolitan areas, where housing market dynamics are less directly tied to climate-sensitive industries or speculative development cycles. Instead, housing prices in these markets may be driven by fundamentals such as population growth, employment, and interest rates.[9] Additionally, these metros may have implemented more effective climate adaptation measures post-recession, reducing their vulnerability to CPU.

5.4. Broader Policy Uncertainty: EPU as a Control

The EPU index exhibits significant predictive power over the CPU, validating our empirical specification. Controlling for EPU isolates the CPU-specific transmission channel rather than capturing generic policy uncertainty. The linkage reflects political economy dynamics in which fiscal, tax, or monetary policy volatility creates an unstable environment that affects the timing and credibility of climate initiatives. When overall economic uncertainty rises, governments often delay or modify climate policies to prioritize short-term stabilization, thereby increasing CPU. Past EPU values also shape investor expectations and signal potential regulatory shifts, thereby reinforcing the transmission from EPU to

CPU. This pattern was evident during the 2007–2009 recession, when economic instability redirected priorities toward stabilization despite green stimulus measures.

5.5. Robustness Check: Common Lag Length Specification

Since the methodological framework selects optimal lag lengths using the SIC criterion, results and inferences may depend on the chosen lag structure. To assess robustness, we re-estimate the Fourier-augmented TY model imposing a common lag length of 12 months (p = 12) across all metropolitan CPU systems. This sensitivity analysis, reported in Table 5, reduces reliance on information criterion-based lag selection and tests whether the identified transmission patterns persist under a uniform one-year, monthly horizon. The core finding of statistically significant *CPU* → *housing prices* transmission persists across a broad set of housing markets, including at the national level, indicating that the main results are not driven by metro-specific lag selection.

Table 5. Robustness Analysis: Uniform Lag Specification.

Variables	From CPU	p-Value	To CPU	p-Value
Atlanta	16.6073	0.1650	14.2311	0.2862
Boston	10.6909	0.5556	23.7281 **	0.0221
Charlotte	21.6919 **	0.0411	16.2193	0.1814
Chicago	27.7070 ***	0.0061	8.9337	0.7086
Cleveland	12.5880	0.3997	9.2379	0.6825
Denver	31.8797 ***	0.0014	38.1941 ***	0.0001
Detroit	15.5309	0.2137	18.8567 *	0.0920
Las Vegas	20.1544 *	0.0642	13.0402	0.3661
Los Angeles	27.8195 ***	0.0059	35.2413 ***	0.0004
Miami	40.5563 ***	0.0000	13.7831	0.3148
Minneapolis	8.2889	0.7622	10.4853	0.5735
New York	25.8850 **	0.0111	9.9400	0.6212
Phoenix	51.0783 ***	0.0000	28.1895 ***	0.0052
Portland	40.8273 ***	0.0000	28.0697 ***	0.0054
San Diego	40.7480 ***	0.0000	26.2253 ***	0.0100
San Francisco	21.8447 **	0.0393	24.1397 **	0.0195
Seattle	32.1735 ***	0.0013	16.2476	0.1802
Tampa	21.3718 **	0.0452	11.3736	0.4972
Washington, D.C.	16.2661	0.1794	13.0086	0.3684
USA	31.7002 ***	0.0015	18.6064 *	0.0985

Notes: Re-estimation of the Fourier TY approach using a uniform lag length of 12 months (p = 12) for all metropolitan–CPU systems (instead of the SIC-selected lag length). Wald tests are computed from bivariate $VAR_{(p+d)}$ models in levels with d = 1, a single-frequency Fourier term (k = 1) in the intercept, and the same control variables used in the main specification (EPU, oil and gas prices, 30-year mortgage rate, inflation and unemployment rates, and real disposable income per capita). *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

6. Conclusions

This study examines the relationship between CPU and regional housing prices using novel econometric techniques that account for both abrupt and gradual structural breaks. Given the difficulty in detecting gradual shifts, particular emphasis is placed on their inclusion to mitigate spurious inference. While previous research has examined CPU, limited attention has been given to identifying gradual structural shifts and systematically incorporating them into analytical models. By addressing this shortcoming using the Fourier-augmented TY framework and metropolitan-level data, this analysis provides fresh insights into the spatial and temporal heterogeneity of CPU transmission.

This study demonstrates that CPU operates as a spatially heterogeneous driver of U.S. housing prices across metropolitan areas. Coastal high-exposure markets such as Los Angeles, Miami, New York, San Diego, San Francisco, Seattle, and Tampa show strong *CPU* → *housing prices* transmission, reflecting the combined influence of physical climate risks and regulatory uncertainty. Inland growth markets, including Charlotte, Denver, Phoenix, and Portland, display mixed dynamics shaped by rapid population growth, development cycles, and local policy debates, while Phoenix remains persistently sensitive to CPU because of severe climate risks despite its inland location. Charlotte and Denver consistently exhibit *housing prices* → *CPU* transmission through political economy channels tied to rapid growth, while feedback is absent in economically diversified markets.

Midwest extreme weather markets such as Chicago and Minneapolis also reveal consistent *CPU* → *housing prices* transmission regardless of macroeconomic conditions, suggesting that increasing exposure to climate-related risks can influence housing valuations even outside coastal regions. In contrast, recession-sensitive speculative markets such as Las Vegas exhibit CPU transmission only in the full sample covering periods of economic stress, whereas insulated metropolitan areas, including Atlanta, Boston, Cleveland, Detroit, and Washington, D.C., show no transmission. This insulation could reflect lower physical climate exposure relative to coastal metros, where fundamentals dominate climate policy considerations.

Bidirectional transmission is primarily observed in large, economically significant metropolitan markets, such as Los Angeles, New York, San Diego, and San Francisco, where housing dynamics influence distributional perceptions and policy debate. The U.S. national housing price index further substantiates bidirectional transmission. The *CPU* → *housing prices* channel affects aggregate housing valuations through investment delays, credit market tightening, and homebuyer discounting of future property values due to revised expectations about regulatory costs. Conversely, the *housing prices* → *CPU* channel operates when strong and stable housing market performance generates broader perceptions of macroeconomic stability and wealth creation, providing policymakers with greater fiscal and political capacity to advance climate-related initiatives, including clean energy incentives, emissions regulations, and investments in climate-resilient infrastructure. Housing market instability, by contrast, may shift policy priorities toward short-term economic stabilization, increasing uncertainty surrounding the timing and scope of climate policy implementation.

One interesting finding of the study is that EPU serves as a key determinant of future CPU, highlighting how economic instability and environmental governance are intertwined. Past EPU values create unpredictability that spills over into climate policy, where government priorities, investor behavior, and global trends amplify or mitigate uncertainty. The *CPU* → *housing prices* transmission channel strengthens in the full sample as the relationship evolves and climate policy becomes increasingly economically consequential. Structural breaks are evident in the appearance of CPU-sensitive metros like Las Vegas and Tampa, and the disappearance of Atlanta and Washington, D.C., in the full sample. Our findings are consistent with those reported by Baldauf et al. (2020), Cho et al. (2024), and Donadelli et al. (2020).

Future research can extend the present analysis by examining whether the structural shifts documented in level-based transmission also characterize volatility transmission between CPU and housing prices. A natural extension is to examine whether historical

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volatility in CPU has predictive power for subsequent volatility in metropolitan-level housing price indices and vice versa, while allowing for both abrupt and gradual breaks in the volatility process.

7. Policy Implications

The results indicate that CPU is not priced uniformly across U.S. housing markets, with important implications for financial regulation and policy design. These findings carry direct implications for asset pricing, risk management, and policy design. For investors, CPU represents a priced systematic risk factor across a broader set of metropolitan markets, requiring hedging strategies and portfolio rebalancing. For homeowners in climate-exposed markets, property values respond to climate policy trajectories, increasing long-term valuation uncertainty. For policymakers, the broadening transmission pattern implies that shifts in climate policy expectations generate asymmetric wealth effects across regions, notably in high-value coastal markets, and affect a larger share of U.S. households. Policymakers should account for these distributional impacts when designing climate regulations. Compensatory mechanisms, such as adaptation grants, tax credits, or insurance subsidies, may be necessary for households in high-exposure, CPU-sensitive markets to mitigate regressive wealth effects and political economy obstacles to climate action.

For mortgage lenders, credit risk models should incorporate CPU-driven collateral volatility, particularly in coastal and wildfire-prone markets. The pronounced spatial heterogeneity observed across several metropolitan areas highlights the importance of geographic granularity in policy implementation. Stress-testing frameworks for mortgage and real-estate markets should incorporate CPU scenarios calibrated to location-specific transmission patterns rather than uniform national adjustments that obscure concentrated vulnerabilities. Financial regulators should integrate location-specific climate hazard and transition-risk measures into underwriting, collateral valuation, and supervisory reporting, differentiating CPU-related capital requirements, provisioning standards, and stress test scenarios across metropolitan markets based on empirically documented transmission strength.

The presence of bidirectional transmission in several large metropolitan markets suggests that policy uncertainty and housing market dynamics may reinforce each other through feedback effects. Transparent policy design and communication, supported by credible long-term commitments regarding the timing, scope, and enforcement of climate-related regulations and infrastructure investments, could reduce uncertainty premia and feedback effects in local housing markets. In addition, proactive climate adaptation measures may reduce housing market sensitivity to CPU by lowering physical exposure and demonstrating regulatory preparedness.

The finding that EPU significantly predicts CPU underscores the importance of coherent and predictable policy frameworks when climate-related regulations affect household balance sheets, credit conditions, and property valuations. Policymakers should coordinate fiscal, monetary, and climate policy communication to minimize compounding uncertainties that amplify housing market volatility. Federal financial regulators and housing finance authorities should monitor CPU alongside macro-financial indicators, particularly in metropolitan areas experiencing rapid housing appreciation or stress, as these dynamics may facilitate or impede climate policy implementation through feedback effects. These findings highlight the necessity of integrating CPU into housing market oversight and financial stability frameworks, especially where climate exposure, housing valuations, and policy sensitivity intersect.

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Notes

1. As of 29 February 2024, the NFIP had over 4.7 million flood insurance policies providing over $1.3 trillion in coverage (Horn and Webel 2024).
2. While the U.S. lacks a federal carbon tax, several regional initiatives exist, including California's cap-and-trade program and the Regional Greenhouse Gas Initiative (RGGI) covering northeastern states.
3. The Federal Housing Finance Agency (FHFA 2024) identifies climate transition risk as a systemic challenge for the housing finance system, calling for improved risk disclosure and regulatory frameworks.
4. The TY framework tests Granger causality without requiring pre-testing for cointegration, accommodating variables with different orders of integration.
5. To conserve space, the full derivation and detailed explanation of the model are not presented here. Interested readers are referred to Nazlioglu et al. (2016, 2019) and Gormus et al. (2018) for further details.
6. Dallas has been excluded from the analysis because the series is only available from January 2000 onward, limiting comparability with the other metropolitan areas in our full sample.
7. However, the results for the additional controls are not reported in Section 5 to maintain brevity.
8. See https://archive.epa.gov/epa/cleanpowerplan/fact-sheet-overview-clean-power-plan.html (accessed on 9 December 2024) and https://www.irs.gov/inflation-reduction-act-of-2022 (accessed on 9 December 2024) for more information.
9. Similarly, Washington, D.C., despite being a political hub, may exhibit limited sensitivity to CPU because its housing market is heavily influenced by federal employment, federal spending and policy priorities, and international institutional presence, with lower physical climate exposure.

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