

Economic Condition, Climate Change and Housing Affordability in Fifty (50) United States and the mediating role of interest rate: Some Panel Data Evidence

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**Economic Conditions, Climate Change, and Housing Affordability Across U.S. States:
The Mediating Role of Interest Rates in a Panel Data Analysis**

Abstract

The study offers a nuanced exploration of the complex relationship between economic conditions and environmental challenges that impact housing affordability across the 50 federated states in the U.S. While we acknowledge the significant connection between housing affordability and economic factors, we hypothesize that extreme weather events and environmental risks are critical in diminishing housing quality. This decline can lead to reduced demand and notable price decreases for properties in vulnerable areas. Using the Panel ARDL model, we effectively capture both the long-run and short-run dynamics of this relationship while also considering each state's distinct economic and weather conditions. We categorize states into the hottest and coldest regions to elucidate the mediating role of interest rates within this nexus. Our rigorous analysis spans the period before and after the global financial crisis (GFC), lends credibility to our findings. Our results demonstrate that improved economic conditions significantly enhance housing affordability across various states. However, this positive effect tends to be fleeting, with colder regions exhibiting a more enduring impact. Furthermore, our comprehensive analysis reaffirms that favourable economic conditions consistently bolster housing affordability, reinforcing this connection regardless of the timeframe examined. Importantly, we highlight the substantial role of interest rates in linking economic conditions to housing affordability. This evidence suggests that interest rates significantly influence housing affordability over the long term, underscoring the necessity of maintaining favourable interest rates to improve housing affordability considerably over time. This insight invites strategic policy considerations to ensure sustainable housing solutions amidst ongoing economic and environmental challenges.

Keywords: Economic conditions; Housing; Climate change; Interest rate; P-ARDL

JEL Codes: A10; R21; R31; Q54; E40; B41.

1. Introduction

The issue of housing affordability is a serious concern as it affects households' ability to cover housing expenses without sacrificing other essential needs. Many families are forced to cut back on food, clothing, healthcare, education, and other vital investments due to the high cost of housing. In some cases, housing prices have even driven households into debt to make ends meet. However, housing affordability is not solely dependent on economic conditions. While a stable economy can make housing more affordable, other factors, such as household characteristics and housing factors, also play a role. Additionally, macroeconomic indices such as GDP, income growth, inflation rates, unemployment rates, and mortgage rates fluctuate over time, which can impact housing affordability across countries (McQuinn & O'Reilly, 2008; Fadiga & Wang, 2009; Adam & Füss, 2010; Bjørnland & Jacobsen, 2010; Agnello & Schuknecht, 2011; Zhang et al., 2012; De Wit et al., 2013; Cohen & Karpavičiūtė, 2017; Aliyev et al., 2019; Karpestam & Johansson, 2019, Bangura & Lee, 2023).

There is no denying that the above-mentioned studies provide compelling evidence of the significant relationship between housing affordability and economic factors. However, it is essential to recognize that housing affordability is also influenced by the location and climate of properties. The global housing crisis has been exacerbated by the growing impacts of climate change, with low-income populations being disproportionately affected (Levy & Patz, 2015). As urban migration continues to rise, the potential for exacerbating climate challenges becomes increasingly evident. Constructing taller buildings may lead to increased energy consumption, greater reliance on vehicles, and substantial damage to crucial natural ecosystems that support biodiversity, all of which contribute to heightened carbon emissions. Moreover, the severe impacts of climate change, such as extreme weather events, further aggravate the housing crisis by reducing the availability of affordable housing and driving up costs. Notably, over ten million homes were lost to climate-related disasters in 2021, underscoring the urgent need for proactive measures (Fu, 2022). Research by Harrison et al. (2001) indicates that properties located in flood zones tend to sell for significantly less than those situated outside these areas (see also Wetzstein, 2017; Gibson et al., 2018; Bernstein et al., 2019; Apergis, 2020; Bezgrebelna et al., 2021).

In the aftermath of the 2008 subprime mortgage crisis, substantial evidence emerged connecting interest rates—an integral aspect of monetary policy—to mortgage rates and housing affordability.

While early studies suggest that a robust causal relationship between lower interest rates and housing market booms is lacking (Bernanke, 2010; Dokko et al., 2011; Kuttner, 2013; Luciani, 2015), more recent literature now convincingly demonstrates that expansionary monetary policy contributes to significant increases in U.S. house prices (see McDonald & Stokes, 2013, 2015; Jorda et al., 2015; Cooper et al., 2016). Nevertheless, even with empirical findings indicating that loose monetary policy drives notable appreciation in house prices, critical questions persist regarding the ability of interest rates to mitigate the impact of climate change on housing affordability. For example, interest rates can play a role in moderating climate change by influencing investment choices and financing opportunities for sustainable projects. Specifically, lower interest rates can make it more feasible for governments and businesses to invest in renewable energy technologies, energy efficiency upgrades, and sustainable infrastructure. This shift can facilitate the transition away from fossil fuels and contribute to a reduction in greenhouse gas emissions. However, pertinent to this study is the question of whether the benefits derived from this moderating role of interest rates are significant within the climate change-housing affordability nexus.

In view of the foregoing, we go beyond the common practice of examine the separate effect of economic conditions, climate change, and interest rate on housing prices, rather we consider the complex interplay of these factors to underscores the implication of their combine effects on the housing affordability of the 50 federated states in the U.S. More so, unlike previous studies that relied on income and GDP as indicators, this study uses new datasets from Baumeister et al. (2021), which cover a wide range of economic factors, including mobility, labour market indicators, real economic activity, expectations, financial indicators, and household indicators, such as expansion and recession variables. These datasets are explained in detail in the data section of the paper. Furthermore, the study examines how extreme weather conditions, both hot (high temperature) and cold (low temperature), impact housing affordability. For instance, during winter, the demand for heating appliances can increase housing prices, making it harder for people to afford housing. The study also considers weather conditions' psychological and emotional effects on decision-making. It is well-known that temperature changes can affect income, productivity, and sales volume. Additionally, data shows that housing prices and transactions tend to follow a seasonal pattern in the U.S., with prices and transactions increasing during spring and summer and

decreasing during autumn and winter. This trend may be due to a rise in demand for housing during the holiday season.

In addition to exploring the impact of economic conditions and climate change on housing affordability, we also investigate the mediating influence of interest rates during low and high-interest rate periods. This is crucial because interest rates significantly determine mortgage accessibility, which is closely tied to our predictor variables. By examining interest rates as a mediating factor, we can better understand how these factors shape housing affordability. In sum, the innovation in this study is to study examine the combined effects of economic conditions and climate change on housing affordability while invoking the mediating roles of interest rates in the nexus. It also examines the influence of the global financial crisis (GFC) and asymmetric economic and weather conditions in our data classifications. Our analysis covers the period between 1987 and 2022, using panel data approaches suitable for long panels such as this (that is, large N – cross sections and large T – time dimensions). In particular, we employ the panel autoregressive distributed lag (PARDL) model that estimates both long- and short-run dynamics in the analysis, given the inherent persistence and heterogeneity effects typical of large cross-sections and time dimensions (see Shin et al., 2014).

As a prelude to our findings, we show that overall, improved economic condition is associated with better housing affordability, as housing becomes relatively more affordable in the cold region than in the hot region across the full sample and high and low economic classifications. The mediating role of interest rate in the nexus is confirmed, especially for hot regions. While considering climate change as a predictor, our results reveal that climate change improves housing affordability across the states and other sub-samples, including the hottest and coldest states, albeit in the short run. In the final set-up, where the mediating role of interest rate is evaluated concerning the nexus between the economic condition and housing affordability, our results adduce the implication of interest rate to long-run phenomenon across all state classifications. In essence, the interest rate improves housing affordability in the long run.

After this introduction, the rest of the paper is organized as follows. Section 2 addresses theoretical issues concerning the relationship between our explanatory and explained variables. Section 3 explains the data and offers some preliminary results. Section 4 provides an overview of the

methodology. Section 5 presents and discusses the results of our empirical findings, and Section 6 concludes the paper.

2. Literature Review

2.1 Channel of transmission of the effects of economic conditions, climate change, and interest rate on housing affordability

The relationship between economic conditions and housing affordability is an important issue that can be effectively examined through the fundamental principles of supply and demand (see Demary, 2010; Rehman et al., 2020; Vaidynathan, et al., Yoon, 2022; 2023). When the economy is strong, demand for housing generally increases due to rising employment rates and greater disposable income, which leads to higher housing prices. Conversely, during economic downturns, demand tends to fall, resulting in a decrease in housing prices that can further complicate affordability. Additionally, the income effect plays a significant role; as individual incomes rise in a thriving economy, purchasing power also increases, allowing consumers to invest more in housing. In contrast, an economic decline that lowers incomes can exert considerable downward pressure on housing prices, exacerbating affordability challenges for many.

From the perspective of credit availability (see Mian & Sufi, 2009, 2010), banks are usually more inclined to lend during prosperous economic times, making mortgages more accessible to potential borrowers. This increase in credit availability not only boosts demand for housing but is also associated with rising prices. However, it is vital to acknowledge that the credit channel interacts with the broader monetary policy framework, particularly regarding interest rates. This highlights the importance of exploring how interest rates mediate the connection between economic conditions and housing affordability. Standard economic theory supports the idea that lower interest rates can enhance housing values by making financing for home purchases more affordable ((Egert & Mihaljek, 2007; Adams & Füss, 2010; Tripathi, 2019). Therefore, there is a strong case for investigating how monetary policy (interest rate) can help temper the effects of economic conditions on housing affordability.

Regarding the channel of the transmission of the effect of climate change on housing affordability, one of the most immediate ways climate changes affect housing prices is through natural disasters (see Baldauf et al., 2020). Areas prone to flooding, wildfires, or hurricanes often see a decline in

property values (see Bernstein et al., 2018; Murfin & Spiegel, 2018). This can create localized housing shortages in safe areas, leading to increased demand and higher prices in those markets, while simultaneously causing price declines in areas experiencing population loss.

In view of the foregoing, among other things, we provide in the following, a succinct review of the findings of the existing literature on the connections between housing affordability and the key factors under consideration amid the various channels highlighted. The literature discussing the influence of economic conditions on housing affordability is covered in Section 2.1, while Section 2.2 examines the effects of climate change on housing affordability. Lastly, Section 2.3 explores the impact of interest rates on housing affordability.

2.2 Economic Conditions and housing affordability

The theoretical link between economic conditions and housing affordability can be viewed bidirectionally. On the one hand, increased housing price/rent, which necessitates a higher proportion of household income on housing, discourages consumption and deters households from investing in other business opportunities, which in turn slows the growth of an economy (economic contraction) (see also McPherson, 2019; Schweitzer, 2019). Similarly, speculations about housing demand (and affordability) have been linked to economic expansions (see Justiniano et al., 2019). Intriguingly, local economic expansions have been documented where speculation increased throughout the housing boom period, whereas subprime credit expansion was more pronounced in areas where local economic contractions ensued (Gao et al., 2020). On the other hand, it is expected that during expansion periods, income growth would match up with or even exceed increases in housing costs, thereby bringing down the burden associated with rising house prices (see Anthony, 2022). A contrary view suggesting no nexus between economic expansions and housing affordability has also been suggested (see Anthony, 2018). Given the multiplicity in the theoretical outcomes of economic condition and housing affordability, this study attempts to establish what economic condition portends for housing affordability, particularly in the United States. Wetzstein (2017), Meen & Whitehead (2020), and Lee et al. (2022) are some of the studies that have also considered the relationship between economic conditions and housing affordability. However, while the bulk of the extant studies mentioned herein considered economic conditions in terms of aggregate demand and mainly from the viewpoint of the concepts of economic expansion and

contraction, it is instructive that by design, the measure for economic conditions in this study encapsulates the various indicators that capture the economy conditions of the U.S economy.

2.3 Climate Change and housing affordability

The theoretical relationship between housing prices and climate risk factors has been linked to the efficient market theory. Efficient housing markets suggest that the costs of any two properties must converge, considering differences in location and available amenities. Harrison et al. (2001) extended this theoretical idea to pricing environmental attributes of different housing locations. They hypothesize that selling prices of properties in flood-designated zones should be significantly lower than those outside of these environmentally sensitive areas and that the reduction in value should be equal to the present value of all foreseeable flood insurance premiums. In other words, extreme weather events that diminish houses' quality tend to lower housing prices, given a low demand for properties in areas susceptible to this extreme climatic condition. This latter position tends to find support in the study by Bernstein et al. (2018), who estimate a discount in home prices of 7% due to exposure to sea-level rise (see also Bin & Landry, 2013; D'Acunto & Rossi, 2017; Boustan et al., 2017; Wetzstein, 2017; Gibson et al., 2018; Bernstein et al., 2019; Bezgrebelna et al., 2021). In the analysis of natural disasters and housing prices with fresh evidence from the global country sample, Apergis (2020) not only documents that physical climate change, such as natural disasters, leads to lower house prices, but when examining the nexus across different types of natural disasters, the study finds that it is the geological disasters that exert the strongest (negative) impact on house prices. However, not only are the bulk of these studies predominantly focused on individual locations, especially in the U.S., but they have yet to consider the possibility of the nexus being sensitive to different climatic dimensions. As a result, we use the case of the 50 federating states in the U.S. to account for the possibility of heterogeneity in the nexus by categorizing the states into two groups. The first comprises states with averages of annual temperature ranging from 10 degrees Celsius and above and categorized as the hottest region, while the second group, defined as the coldest regions, comprises a state with averages of annual temperature from +9.9 degrees Celsius and below. Essentially, the effect of climate change on housing affordability may vary for states with high temperatures (hottest region) compared to states with low temperatures (coldest region).

2.4 Interest Rate and housing affordability

A long-standing relationship exists between interest rate as a monetary policy anchor and mortgages, and by extension, housing affordability. Available evidence suggests that to enhance household affordability and sustain the prices of assets, including houses, during the Great Recession, the Federal Reserve significantly lowered the overnight lending rate target and made massive acquisitions of mortgage-backed securities (see Di Maggio et al., 2017). Pinning this on the credit channel theory, changes in the interest rate have implications for housing affordability. Higher interest rates result in higher costs associated with mortgages, including monthly payments, for example, and the amount of interest to be paid. The opposite holds for a reduction in mortgage payments owing to a reduction in interest rate, albeit for only households with adjustable-rate mortgages (ARM) (Jappelli & Scognamiglio, 2018), at least in the short run, as borrowers of fixed-rate mortgages (FRM) are only impacted by long-term interest rates (Badarinza et al., 2018). In this instance, the additional credit gained by adjustable-rate mortgage holders through lower interest rates could be utilized to increase consumption expenditures. It could even lead to specific households reducing their debt burden when they deleverage (see Keys et al., 2014). Unlike the aforementioned studies, this research innovatively shifts away from the typical practice of directly analyzing the relationship between housing prices and interest rates. Instead, it explores the role of interest rates as a moderating factor in the effect of climate change on housing affordability across all 50 states in the U.S. This approach offers the potential for deeper insights into the intricate dynamics affecting housing markets today.

3. Data and Preliminary Results

Our data covers the period between 1987 and 2022 for all variables of interest, and this scope is motivated by the need to have balanced datasets for all the states covered. In the quest to test the robustness of the nexus across some structural events of global repute alleged to have altered the economic conditions, we further partition our dataset into sub-samples to enable us to determine the episodic dynamics of our finding for the periods before and aftermath of such structural events. Indeed, there have been a few such structural events of global repute, such as the global financial crisis (GFC) of 2008 and recent COVID-19 outbreaks, which have been the most discussed in literature. However, while COVID-19 is a health-related event with its economic implication burnout of the lockdown initiative meant to mitigate the spread of the pandemic, directly related

to the nexus being considered in this study is the GFC, which defines the period of the American subprime mortgage crisis that led to the collapse of the U.S. housing bubble resulting to the devaluation of housing-related securities. On this note, we give preference to the GFC as the appropriate structural event to be considered in this study. We use a dummy variable approach to capture the pre-GFC sample spanning 1987 to 2007, while the post-GFC samples cover between 2008 and 2022. In addition, we categorize the cross-sectional unit into two climatic regions, which are defined as the hottest and coldest regions. The hottest region comprises the U.S. states, with annual temperature averages ranging from 10 degrees Celsius and above. In comparison, the coldest region comprises states with annual temperature averages from +9.9 degrees Celsius and below.

With regard to the measurement and source of data, we obtain data for the U.S. state-level economic conditions (STATECON) from <https://sites.google.com/site/cjsbaumeister/datasets>, whose construction is attributable to the work of Baumeister et al. (2021). The index uses a novel dataset of weekly economic conditions indicators for the 50 states of the United States dating back to 1987. These indices are based on mixed-frequency dynamic factor models with weekly, monthly, and quarterly variables covering various state economy aspects. The variables are broken down into six major categories: mobility measures, labour market indicators, real economic activity, expectations measures, financial indicators, and household indicators. This arrangement allows for a suitable mixture of various frequencies for various variable representatives of the state economies. For the state-level housing affordability, it is measured in terms of the movement in single-family house prices, which is broadly tracked by the Federal Housing Finance Agency (FHFA). This movement is captured in House Price Index (HPI). The HPI analyzes average price changes in second-hand sales or refinancing on the same properties. Thus, it is a weighted repeat-sales index. The data is gathered by looking at reoccurring mortgage transactions on single-family homes whose mortgages had been bought or securitized by Freddie Mac or Fannie Mae since January 1975.⁵ The state-level climate change is measured as the deviation of actual temperature

⁵The HPI can be obtained from this link <https://www.fhfa.gov/DataTools/Downloads/Pages/House-Price-Index-Datasets.aspx#mpo>

(TEMP) from the average, which is technically described as a temperature anomaly.⁶ The U.S. 3-Month Treasury Bill Rate (3M-TBR0 is the proxy for interest rate (INTR) in this study.⁷

Presented in Table 1 are summary statistics for each of the variables under consideration and across the 50 U.S. federated states under consideration. A cursory look at the table shows that the mean value for housing prices is between 94.69 for Michigan State and 142.06 for California, indicating relatively more housing affordability in Michigan and other states than in California. Regarding the level of dispersion, the HPI in Ohio has the lowest standard deviation value at 24.14, which makes housing affordability in the state the least volatile. In contrast, California and Washington, with standard deviation values of 63.79 and 63.22, are the states where the housing prices are the most volatile. Regarding the distribution statistics, the housing affordability data are positively skewed except for Illinois and West Virginia, while more than 15 states are leptokurtic. On average, nearly all the states have improved economic conditions with positive average values, such as Alaska, Massachusetts, South Dakota and West Virginia are the only states with negative economic conditions at least on average. As for the temperature anomaly, the average value of the temperature ranges between 0.50 degree Celsius for Alabama and 2.06 for New Jersey. They are mostly dispersed, with more than half of the states having more levels of dispersion than the mean values. In terms of skewness, about half are skewed to the left, while others skew to the right. For the kurtosis, they are mostly platykurtic except for a few (five in number) that are relatively peaked. All the states take the same interest rate as the entire U.S.; the mean value is 3.32, with a deviation of about 2.7. It is positively skewed and platykurtic. Casual observation of the graphical analysis among the variables indicates that the relationship between housing affordability and other variables, as used in this study, is in the opposite direction for all the states.

⁶ The climate change data is obtained from National Oceanic and Atmospheric Administration (NOAA) and is available at https://www.ncei.noaa.gov/access/monitoring/climate-at-a-glance/statewide/time-series/3/tavg/all/1/1950-2022?base_prd=true&begbaseyear=1901&endbaseyear=2000.

⁷ The (3M-TBR) is sourced from the FRED database of the Federal Reserve Bank of St. Louis, available at <https://fred.stlouisfed.org/series/DTB3>.

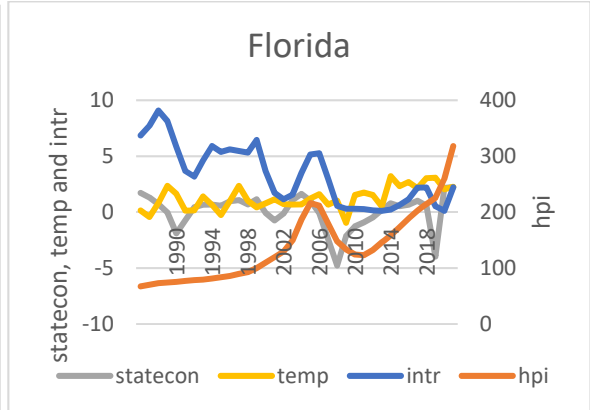
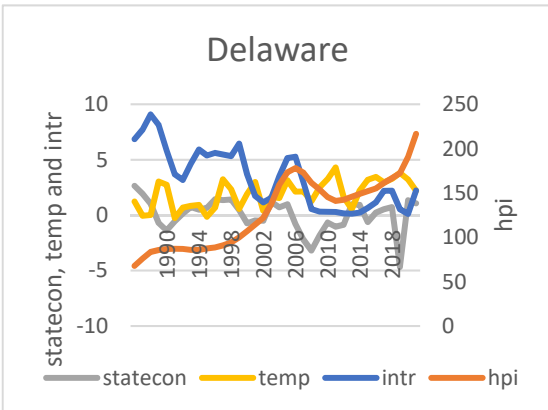
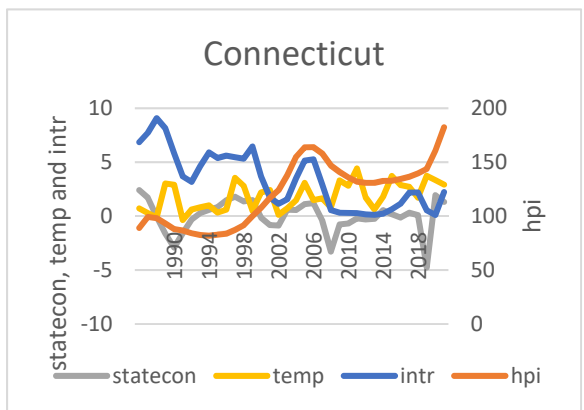
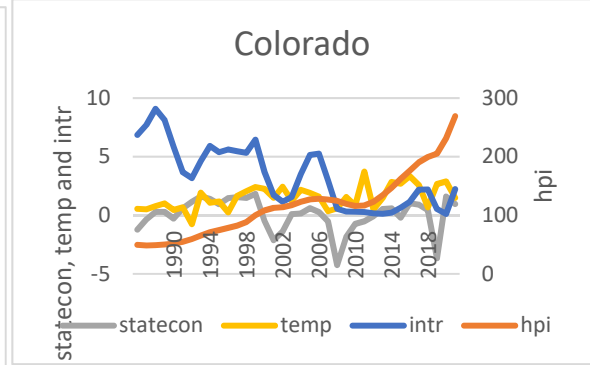
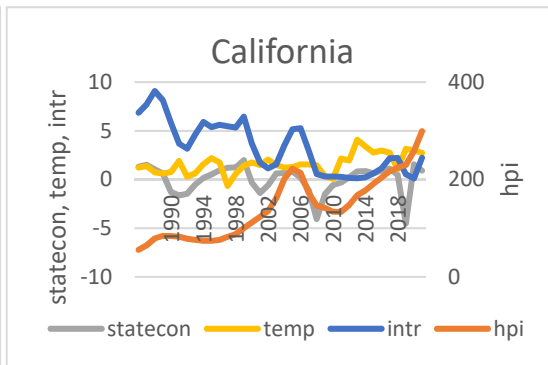
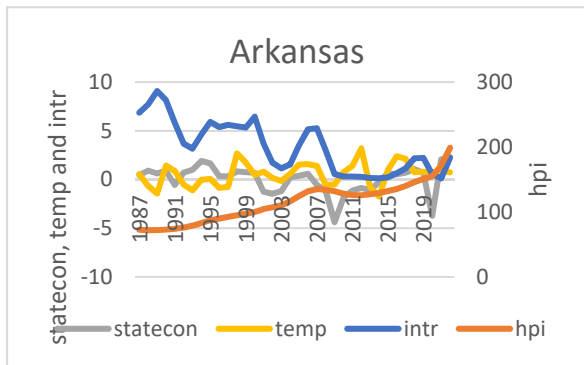
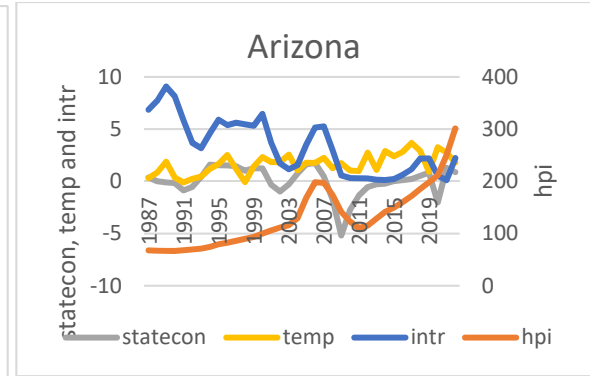
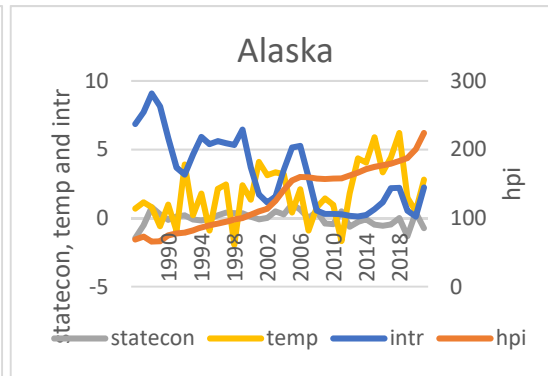
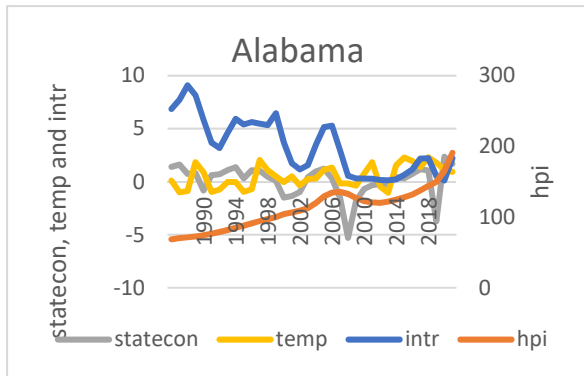
Table 1: Summary Statistics

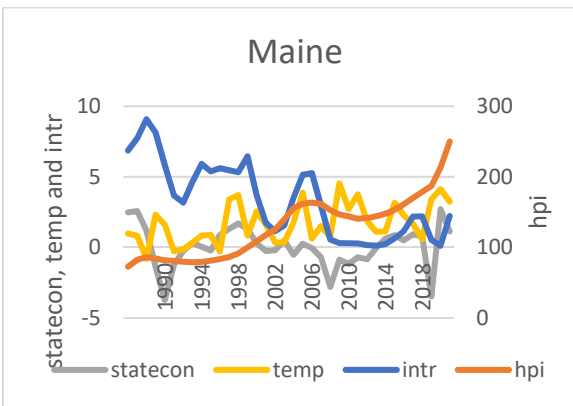
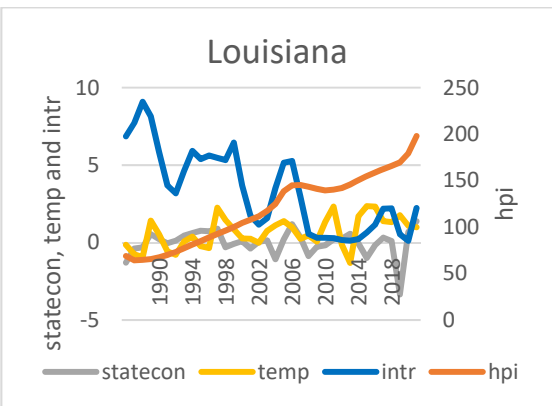
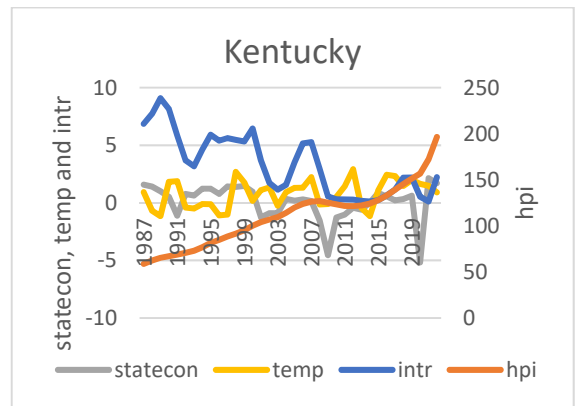
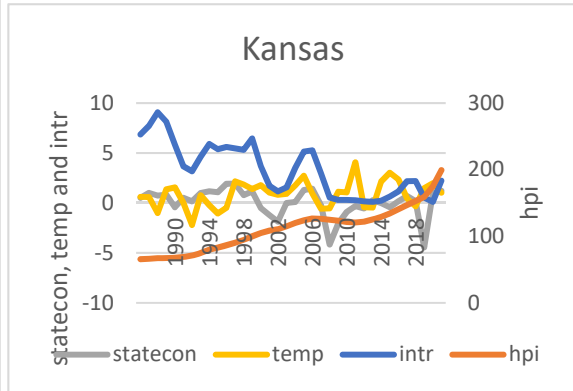
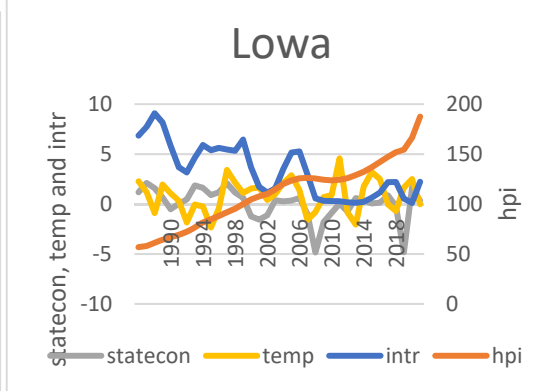
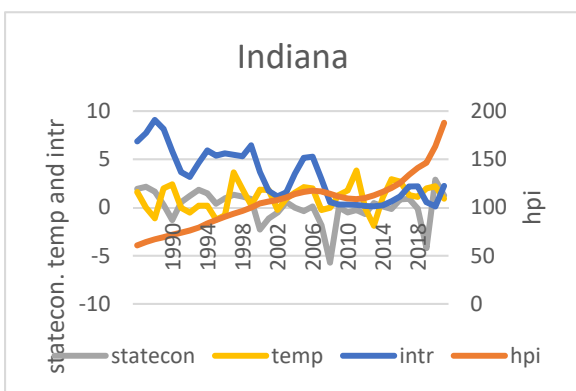
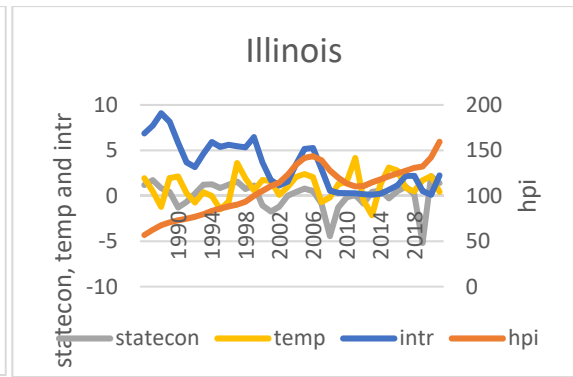
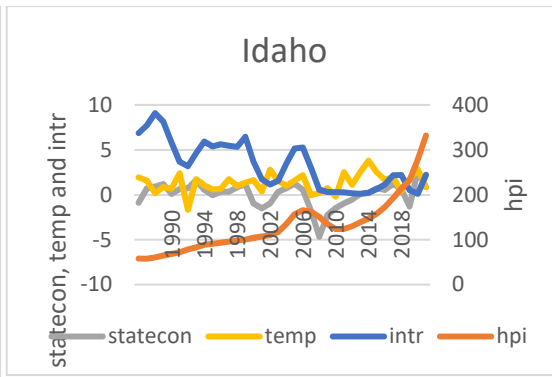
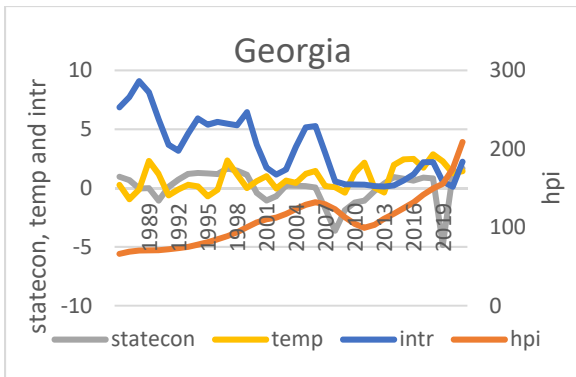
Country	HPI				STATECON				TEMP				INTR				Obser
	Mean	S_D	Skew	Kurt	Mean	S_D	Skew	Kurt	Mean	S_D	Skew	Kurt	Mean	S_D	Skew	Kurt	
Alabama	111.59	29.01	0.40	2.92	0.10	1.51	-1.69	6.42	0.50	1.05	0.14	1.78	3.32	2.66	0.39	1.98	36
Alaska	129.80	45.24	0.11	1.73	-0.04	0.53	-0.63	3.55	1.81	2.00	0.18	2.54	3.32	2.66	0.39	1.98	36
Arizona	129.81	57.65	0.97	3.56	0.04	1.41	-1.58	6.53	1.66	0.97	0.03	2.22	3.32	2.66	0.39	1.98	36
Arkansas	114.63	30.93	0.42	2.87	0.02	1.43	-1.18	4.69	0.54	1.16	0.12	2.58	3.32	2.66	0.39	1.98	36
California	142.06	63.79	0.53	2.31	0.03	1.44	-1.50	5.30	1.63	1.02	0.22	2.87	3.32	2.66	0.39	1.98	36
Colorado	116.53	54.44	0.85	3.41	0.06	1.40	-1.34	4.82	1.53	1.00	0.13	2.51	3.32	2.66	0.39	1.98	36
Connecticut	121.01	29.25	0.12	1.83	0.02	1.50	-1.16	4.74	1.85	1.30	0.10	1.79	3.32	2.66	0.39	1.98	36
Delaware	128.47	39.41	0.18	1.87	0.02	1.46	-1.09	4.61	1.93	1.26	-0.14	1.88	3.32	2.66	0.39	1.98	36
Florida	138.31	61.85	0.89	3.27	0.06	1.55	-1.39	4.88	1.26	1.02	0.10	2.45	3.32	2.66	0.39	1.98	36
Georgia	108.49	32.35	0.89	3.97	0.04	1.42	-1.63	5.89	0.82	1.06	0.27	1.90	3.32	2.66	0.39	1.98	36
Idaho	130.54	61.38	1.39	5.09	0.05	1.33	-1.29	5.74	1.33	1.05	-0.27	3.70	3.32	2.66	0.39	1.98	36
Illinois	107.53	26.58	-0.18	2.03	0.04	1.53	-1.76	6.56	1.01	1.44	-0.06	2.59	3.32	2.66	0.39	1.98	36
Indiana	105.77	27.69	0.66	3.84	0.11	1.67	-1.54	6.25	1.03	1.37	-0.07	2.43	3.32	2.66	0.39	1.98	36
Iowa	110.31	32.74	0.10	2.40	0.06	1.57	-1.61	6.09	0.84	1.64	-0.03	2.50	3.32	2.66	0.39	1.98	36
Kansas	110.92	33.10	0.45	2.90	0.06	1.42	-1.62	5.82	0.88	1.30	0.00	3.02	3.32	2.66	0.39	1.98	36
Kentucky	110.45	32.57	0.37	2.88	0.08	1.55	-1.78	6.61	0.79	1.18	-0.11	1.87	3.32	2.66	0.39	1.98	36
Louisiana	118.91	38.17	0.05	1.83	0.00	0.82	-1.87	8.88	0.66	0.99	-0.01	2.18	3.32	2.66	0.39	1.98	36
Maine	128.80	43.78	0.56	2.88	0.06	1.46	-0.64	3.74	1.70	1.42	0.32	2.07	3.32	2.66	0.39	1.98	36
Maryland	137.81	48.60	0.10	1.62	0.06	1.52	-1.39	5.81	1.62	1.22	-0.12	1.82	3.32	2.66	0.39	1.98	36
Massachusetts	123.30	44.82	0.27	2.20	-0.02	1.45	-1.22	4.38	1.82	1.34	0.14	1.86	3.32	2.66	0.39	1.98	36
Michigan	94.69	26.24	0.27	2.84	0.05	1.57	-1.66	6.26	1.62	1.63	0.02	2.29	3.32	2.66	0.39	1.98	36
Minnesota	113.27	38.79	0.13	2.13	0.13	1.60	-2.27	8.72	1.61	1.93	-0.08	2.20	3.32	2.66	0.39	1.98	36
Mississippi	110.28	28.24	0.14	2.33	0.08	1.41	-0.86	4.58	0.51	1.05	0.06	1.89	3.32	2.66	0.39	1.98	36
Missouri	112.07	32.05	0.45	2.93	0.05	1.52	-1.28	4.53	0.72	1.38	0.09	2.59	3.32	2.66	0.39	1.98	36
Montana	133.76	60.10	0.63	3.05	0.02	1.39	-1.26	5.54	1.48	1.43	-0.52	2.62	3.32	2.66	0.39	1.98	36
Nebraska	110.87	35.81	0.57	3.17	0.18	1.47	-0.93	4.52	1.10	1.44	-0.31	2.95	3.32	2.66	0.39	1.98	36
Nevada	128.76	53.81	0.98	3.16	0.07	1.49	-1.51	4.81	1.55	1.04	-0.02	2.53	3.32	2.66	0.39	1.98	36
New Hampshire	125.78	44.14	0.45	2.66	0.03	1.53	-0.82	3.52	1.71	1.36	0.17	1.83	3.32	2.66	0.39	1.98	36

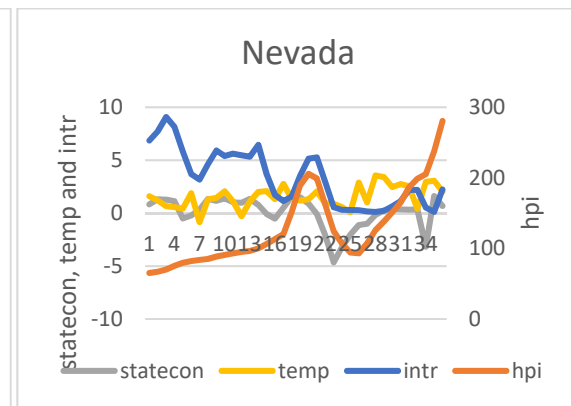
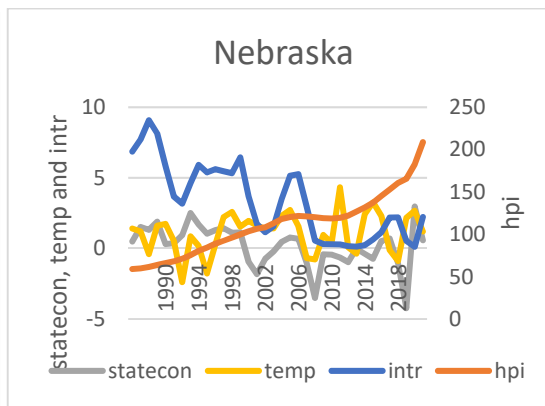
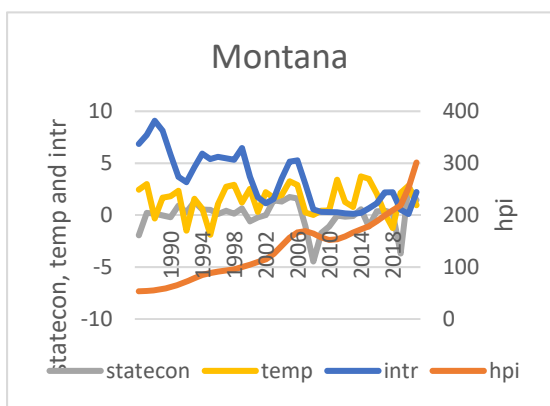
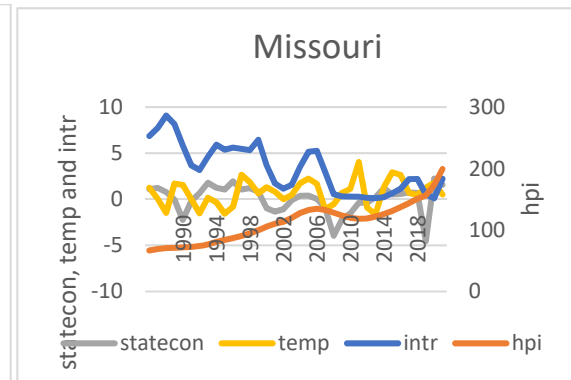
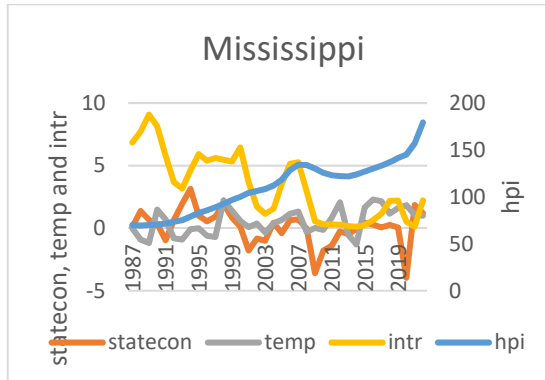
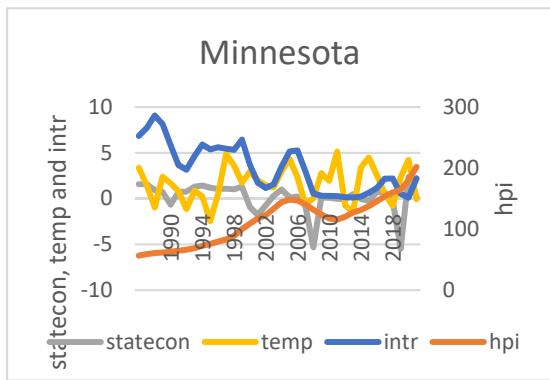
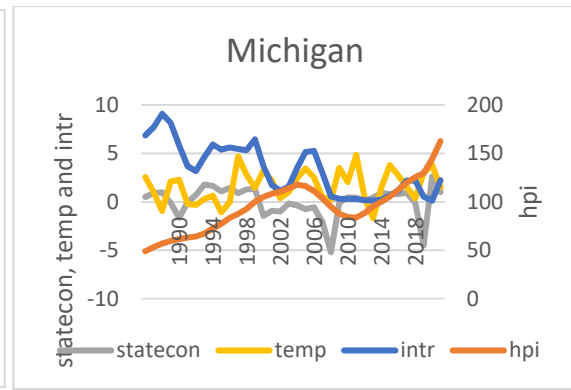
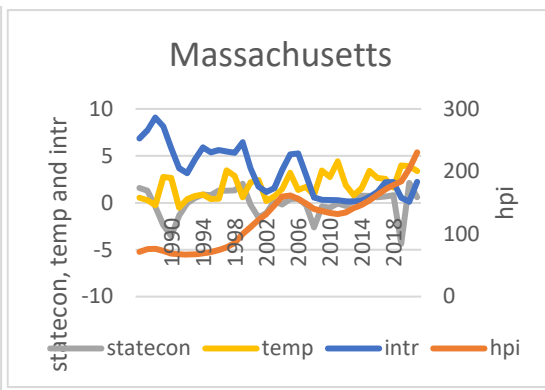
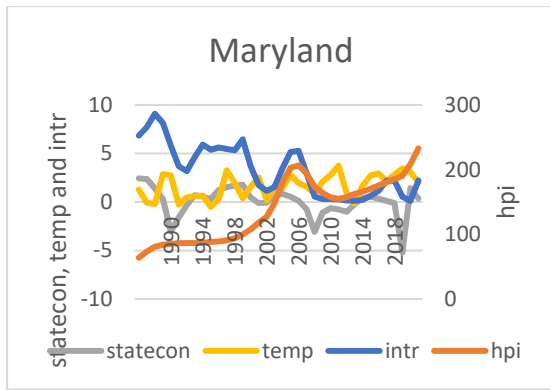
New Jersey	131.35	43.38	0.13	1.74	0.02	1.60	-0.76	3.95	2.06	1.32	-0.13	1.80	3.32	2.66	0.39	1.98	36
New Mexico	120.16	36.73	0.28	2.43	0.08	1.12	-1.48	5.91	1.47	1.04	-0.24	2.61	3.32	2.66	0.39	1.98	36
New York	130.36	43.93	0.25	1.99	0.00	1.48	-1.05	4.25	1.53	1.37	0.13	1.97	3.32	2.66	0.39	1.98	36
North Carolina	112.07	33.90	0.80	3.85	0.01	1.55	-1.22	4.63	1.00	1.08	-0.11	1.93	3.32	2.66	0.39	1.98	36
North Dakota	134.93	54.79	0.46	1.92	0.00	0.73	-0.64	7.31	1.44	1.96	-0.25	2.30	3.32	2.66	0.39	1.98	36
Ohio	101.14	24.14	0.39	3.49	0.08	1.61	-1.89	7.38	1.24	1.33	-0.04	2.01	3.32	2.66	0.39	1.98	36
Oklahoma	117.27	36.20	0.48	2.73	0.00	0.96	-2.23	9.83	0.56	1.20	0.39	2.70	3.32	2.66	0.39	1.98	36
Oregon	128.58	60.51	0.59	2.83	0.05	1.42	-1.52	5.16	1.43	0.95	0.12	3.76	3.32	2.66	0.39	1.98	36
Pennsylvania	125.90	37.67	0.32	2.26	0.03	1.57	-1.39	5.75	1.34	1.27	0.06	1.93	3.32	2.66	0.39	1.98	36
Rhode Island	136.87	48.44	0.41	2.26	0.01	1.44	-1.81	6.32	2.05	1.29	0.02	1.78	3.32	2.66	0.39	1.98	36
South Carolina	113.77	35.19	0.67	3.39	0.04	1.55	-1.29	4.73	0.93	1.06	0.07	1.92	3.32	2.66	0.39	1.98	36
South Dakota	120.79	44.62	0.60	2.97	-0.01	1.30	-1.20	5.26	1.22	1.84	-0.37	2.48	3.32	2.66	0.39	1.98	36
Tennessee	116.38	39.87	1.06	4.30	0.05	1.57	-1.34	5.37	0.73	1.15	-0.01	1.88	3.32	2.66	0.39	1.98	36
Texas	124.60	48.24	1.12	3.84	0.01	1.24	-1.32	4.64	1.03	1.05	0.13	2.21	3.32	2.66	0.39	1.98	36
Utah	121.88	56.94	1.05	4.22	0.01	1.23	-1.24	4.77	1.64	1.08	-0.08	2.05	3.32	2.66	0.39	1.98	36
Vermont	131.34	43.36	0.27	2.10	0.07	1.49	-0.91	4.42	1.70	1.42	0.12	1.91	3.32	2.66	0.39	1.98	36
Virginia	134.18	47.65	0.18	1.82	0.08	1.53	-1.11	4.52	1.14	1.11	-0.19	1.81	3.32	2.66	0.39	1.98	36
Washington	132.06	63.22	0.87	3.40	0.00	1.17	-2.13	8.60	1.18	0.99	0.23	3.08	3.32	2.66	0.39	1.98	36
West Virginia	111.48	27.65	-0.06	2.09	-0.01	0.75	-2.85	15.13	1.01	1.13	-0.07	1.74	3.32	2.66	0.39	1.98	36
Wisconsin	109.98	34.10	0.08	2.50	0.03	1.50	-1.90	6.98	1.48	1.77	-0.04	2.48	3.32	2.66	0.39	1.98	36
Wyoming	134.38	56.69	0.20	2.00	0.00	0.86	-1.14	4.71	1.50	1.18	-0.41	3.57	3.32	2.66	0.39	1.98	36
Aggregate	121.31	44.50	0.90	4.05	3.32	2.62	0.39	1.98	0.04	1.38	-1.43	5.95	1.29	1.36	0.06	2.80	1764

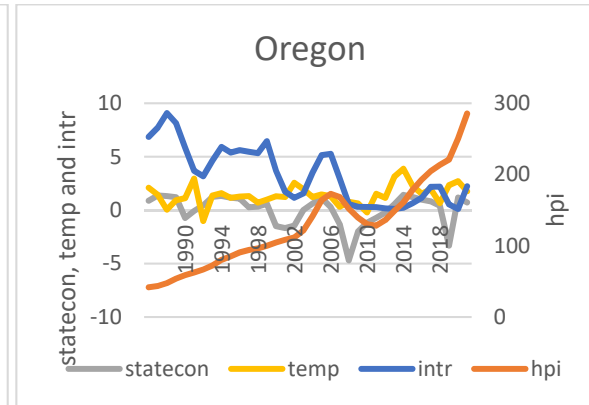
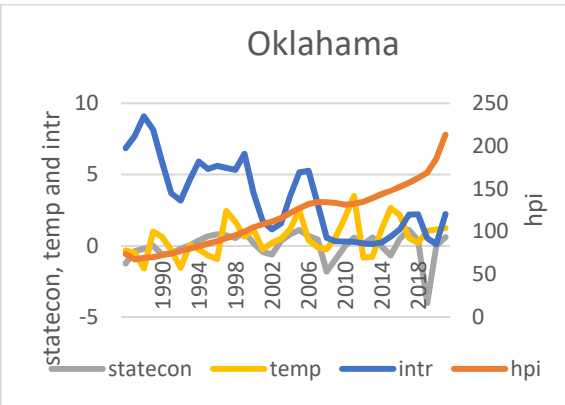
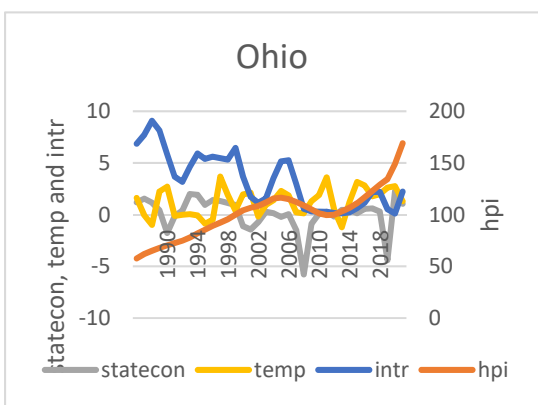
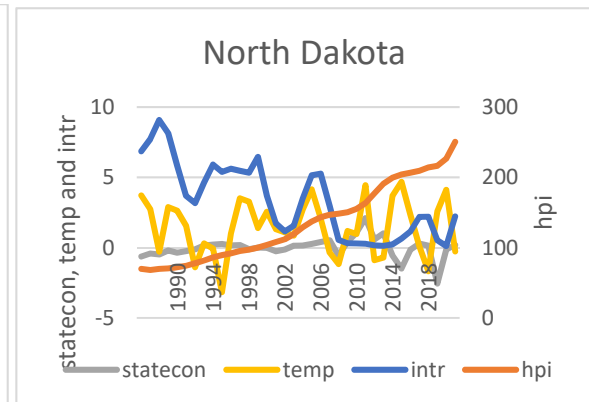
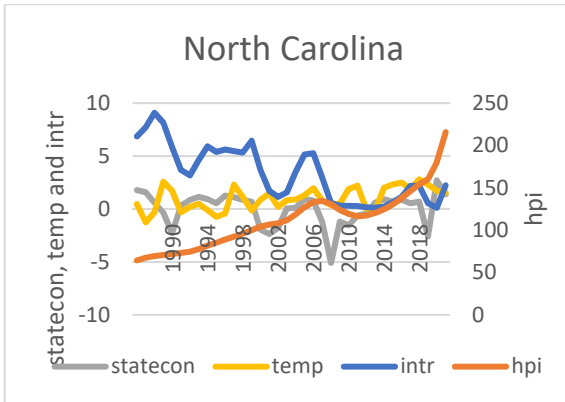
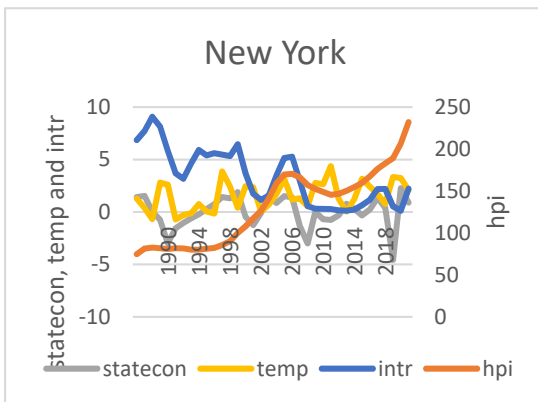
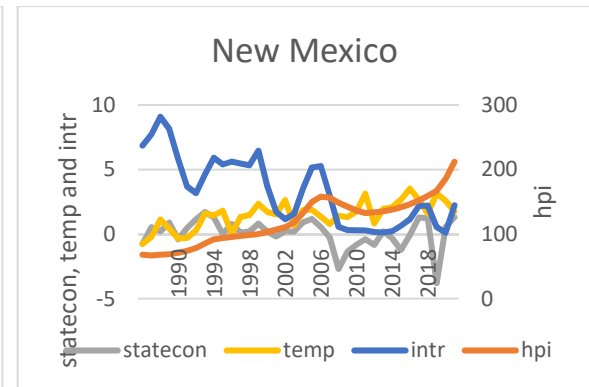
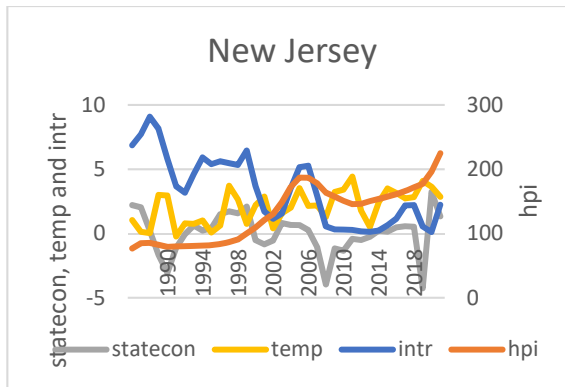
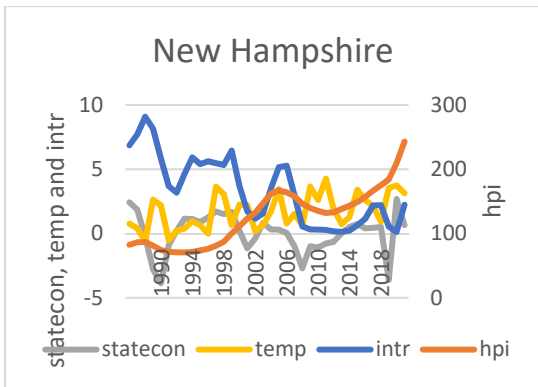
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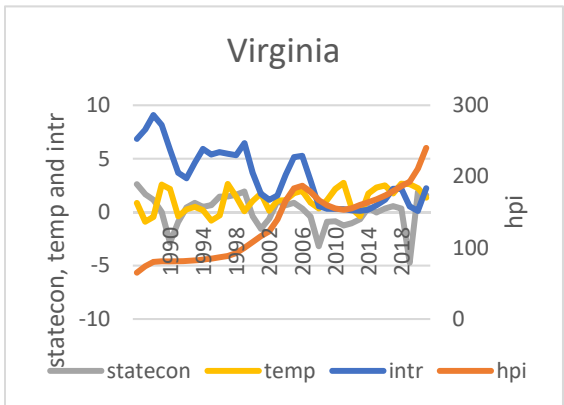
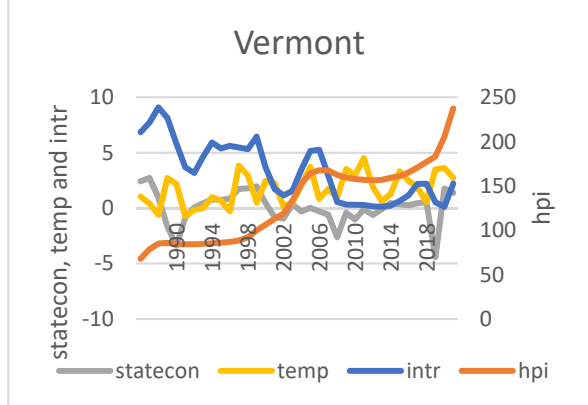
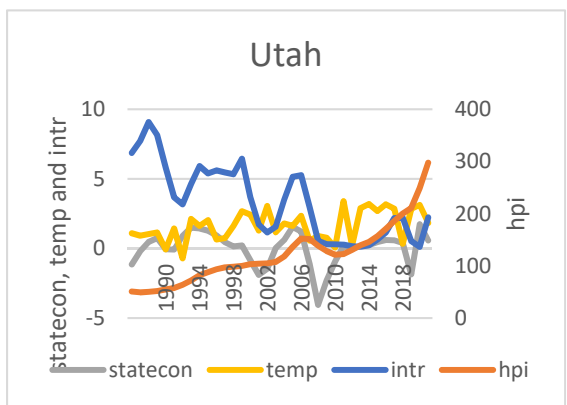
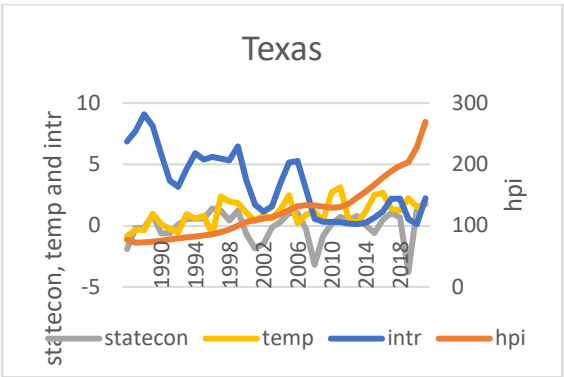
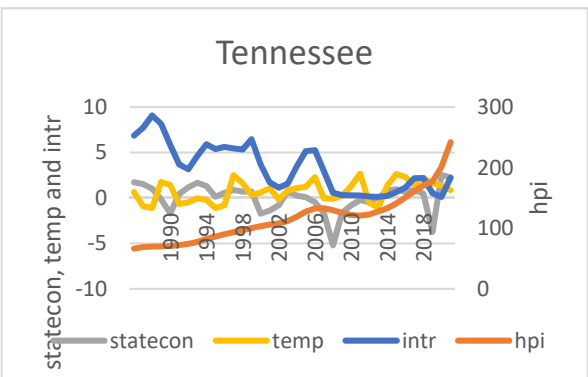
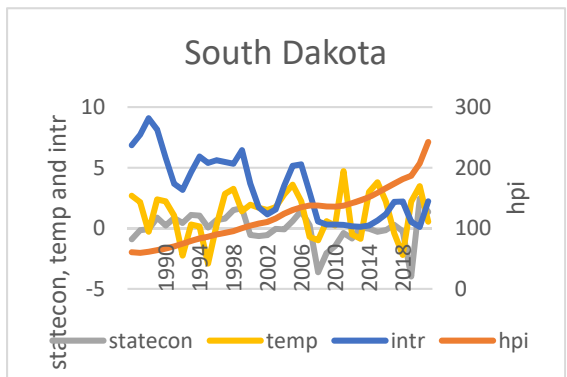
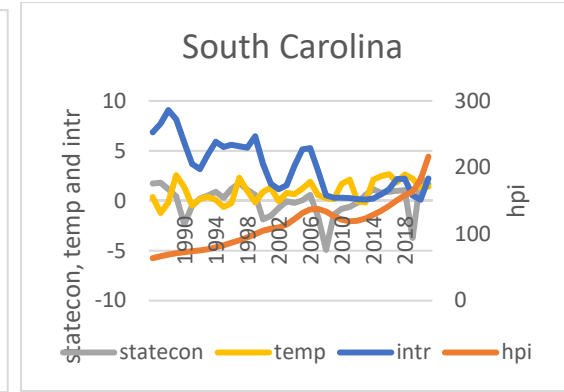
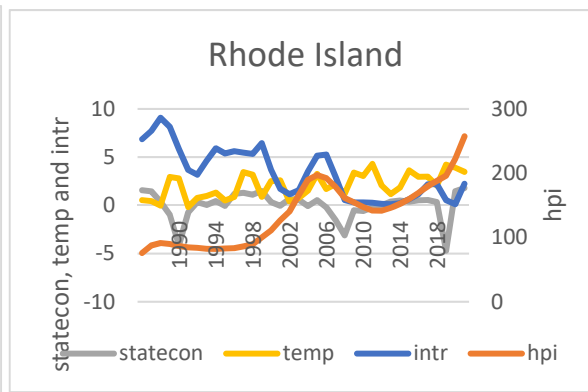
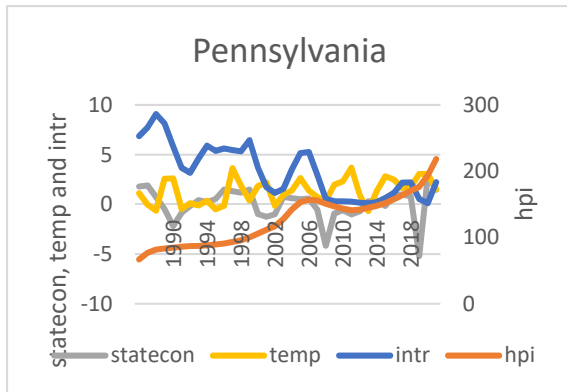
Note: HPI is the state-level housing price index measured as rent to income ratio; STATECON is the state-level economic conditions; TEMP is the state-level temperature anomalies and INTR is for the interest rate.

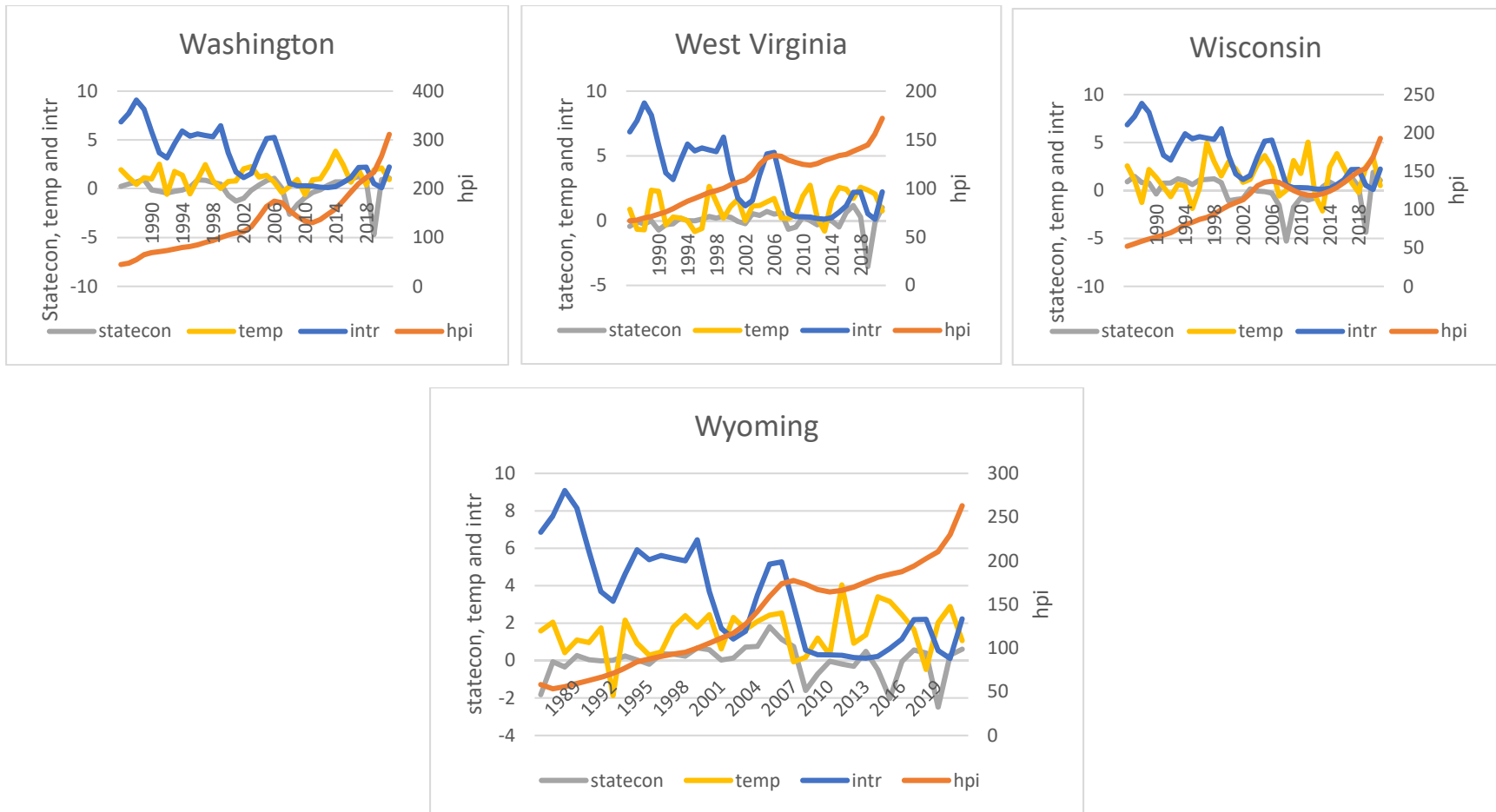












Source: Author's own creation

Figure 1: Co-movement among state economic condition, temperature anomaly, interest rate and housing price-income (HPI) ratio for 50 U.S. states between the years 1987 to 2022

Determining the stationarity of variables is an essential step in modelling panel data with large time series dimensions (T). In Table 2, we present the results from a comprehensive set of panel unit root tests. These tests include the Levin, Lin, and Chu (2002) test (LLC), Harris and Tzavalis (1999) test (HT), Breitung (2000) test, Im, Pesaran, and Shin (1997) test (IPS), and the Hadri (2000) Lagrange Multiplier test. We categorize these tests into non-stationary and stationary based on their respective hypotheses. The non-stationary tests—LLC, Breitung, HT, and IPS assert the existence of unit roots within the panel with distinct alternative hypotheses enhancing their applicability. It is important to note that LLC, Breitung, and HT tests assume a common autoregressive (AR) structure across all series. On the other hand, the IPS test adeptly accommodate heterogeneity in unit root processes for individual cross-sections, significantly strengthening their analysis. The Hadri test, while allowing for a common AR structure, operates on a pivotal distinction, asserting that no unit root exists in any series within the panel, with its alternative hypothesis pointing to the contrary. Our findings decisively demonstrate that the stationarity status of the variables revolved around the I(0) and I(1) orders of integration. This conclusion holds firm across all the various unit root tests we employed, underscoring the robustness and reliability of our results.

Table 2: Panel Unit Root Test Results

	<i>HPI</i>	<i>STATECON</i>	<i>TEMP</i>	<i>INTR</i>
<i>Null Hypothesis: unit root with common process</i>				
<i>LLC</i>	-9.6621 ^{b***}	-26.4643 ^{a***}	-31.9526 ^{a***}	-21.6891 ^{a***}
<i>Breitung test</i>	-3.7881 ^{b***}	-15.3201 ^{a***}	-18.3552 ^{a***}	-3.7435 ^{a***}
<i>H-T test</i>	-3.9500 ^{b***}	-0.3235 ^{b***}	-0.2255 ^{b***}	0.8602 ^{a***}
<i>Null Hypothesis: unit root with individual unit root process</i>				
<i>IPS</i>	-15.8894 ^{b***}	-17.8020 ^{a***}	-17.9943 ^{a***}	-2.0994 ^{a**}
<i>Null Hypothesis: no unit root with common unit root process</i>				
<i>Hadri Z-stat.</i>	17.6723 ^b	-6.0798 ^b	-6.9143 ^b	-4.1926 ^b

Source: Author's own work

Note: The first category of panel unit root test considered includes Levin, Lin and Chu (LLC, 2002), Breitung (2000) and Harris and Tzavalis (H-T, 1999). The second category of unit root tests involving Im, Pesaran and Shin (IPS, 1997) assumes individual unit root process as the null. The third category of unit root tests (i.e. Hadri, 2000 Lagrange Multiplier test) involves the null hypothesis of no unit root with a common unit root process in the panels. The terms *a* & *b* denote stationarity at the level and at the first difference, respectively, while ***, **, and * indicate significance at 1%, 5% and 10%, respectively

4. Methodology

Considering the large cross-sectional (N) and time-series (T) dimensions of the variables of interest, the non-stationary heterogeneous panel data model, namely the panel Autoregressive Distributed Lag (PARDL) model, is deemed the most suitable, among other competing techniques for panel data. The PARDL model has a feature that enables us to simultaneously capture the long-run and short-run estimates of the relationship being examined, and it also has an option to account for the probable heterogeneity in the investigated nexus. In terms of estimation, the two prominent methods in the literature for Panel ARDL analyses are the Pooled Mean Group (PMG) (see Pesaran et al., 1997) and the Mean Group (MG) (see Pesaran and Smith, 1995) estimators. While the difference between the two estimators lies in how long-run estimates are treated, the latter is preferred in this study's context. For instance, while the PMG estimator constrains the long-run coefficients to be equal across groups, all the parameters, such as the intercepts, slope coefficients, and error variances, are allowed to differ across groups in the case of the MG estimator. In addition to being less restrictive, the MG estimator enables us to take full advantage of accounting for more heterogeneous dynamics in the slope coefficients, which also motivates our preference for MG compared to PMG. However, it is instructive that for easy comprehension of the results, we organized our empirical models per each of the three specific objectives of this study and across the three scenarios considered. The first scenario involves an analysis of the three objectives for the total cross-sectional unit of the 50 federated states in the U.S. In the second scenario, the cross-sectional unit is restricted to states with high temperatures and grouped as the hottest region. At the same time, the reverse holds for the third scenario as the cross-sectional unit, which, in this regard, comprises states with low temperatures and is grouped as the coldest region.

4.1 Model formulation for objective 1

This study seeks to explore the crucial relationship between economic conditions and housing affordability by classifying the 50 U.S. states into two climatic regions: those with high temperatures (hottest regions) and those with low temperatures (coldest regions). By examining these distinctions, we aim to gain insights into how this relationship varies depending on a state's temperature classification. Our hypothesis is that the link between economic conditions and housing affordability is significantly influenced by whether a state is categorized as hot or cold.

To facilitate this analysis, we will utilize a Partial Autoregressive Distributed Lag (PARDL) model to effectively connect housing affordability with economic factors:

$$\Delta h_{it} = \rho_{1i} h_{i,t-1} + \alpha_{1i} + \phi_{1i} e_{i,t-1} + \sum_{j=1}^p \lambda_{1ij} \Delta h_{i,t-j} + \sum_{j=0}^q \gamma_{1ij} \Delta e_{i,t-j} + \mu_{1i} + u_{1it} \quad (1)$$

where h_{it} is the log of housing affordability measured as the price-to-income ratio for each i over a time period, t ; e_{it} is the measure of economic conditions; μ_i is for the state-specific effects; u_{it} is the stochastic disturbance term; and Δ is the first difference operator. The long-run impact of economic conditions on housing affordability is measured as $-\phi_i/\rho_i$ while γ_{1ij} measures the short-run impact. There are two extended versions of equation (1) under this objective which accommodate the GFC and asymmetries in the economic conditions as reflected in equations (2) and (3), respectively.

$$\begin{aligned} \Delta h_{it} = & \rho_{2i} h_{i,t-1} + \alpha_{2i} + \phi_{2i}^{PREGFC} e_{i,t-1} * D_t^{PREGFC} + \phi_{2i}^{POSTGFC} e_{i,t-1} (1 - D_t^{PREGFC}) \\ & + \sum_{j=1}^p \lambda_{2ij} \Delta h_{i,t-j} + \sum_{j=0}^q \gamma_{2ij}^{PREGFC} \Delta e_{i,t-j} * D_t^{PREGFC} + \sum_{j=0}^q \gamma_{2ij}^{POSTGFC} \Delta e_{i,t-j} * (1 - D_t^{PREGFC}) + \mu_{2i} + u_{2it} \end{aligned} \quad (2)$$

$$\begin{aligned} \Delta h_{it} = & \rho_{3i} h_{i,t-1} + \alpha_{3i} + \phi_{3i}^{HIGHEC} e_{i,t-1} * D_t^{HIGHEC} + \phi_{3i}^{LOWEC} e_{i,t-1} (1 - D_t^{HIGHEC}) \\ & + \sum_{j=1}^p \lambda_{3ij} \Delta h_{i,t-j} + \sum_{j=0}^q \gamma_{3ij}^{HIGHEC} \Delta e_{i,t-j} * D_t^{HIGHEC} + \sum_{j=0}^q \gamma_{3ij}^{LOWEC} \Delta e_{i,t-j} * (1 - D_t^{HIGHEC}) + \mu_{3i} + u_{3it} \end{aligned} \quad (3)$$

We differentiate the equations by using serial numbers in the subscript where 1, 2 and 3 are for equations (1), (2) and (3), respectively. This representation is particularly important for parameters that are common to all the three questions, that is, ρ , α , λ , μ and u and may be difficult to differentiate them without some additional notations such as those suggested. Note that we present the GFC-augment model in equation (2) and the asymmetric economic conditions based on high and low economic conditions are introduced in equation (3). We separate the pre- and post-GFC estimates with the use of dummy variables where D_t^{PREGFC} is the dummy variable for the pre-GFC and takes the value of one from 1987-2007 and zero otherwise, and $(1 - D_t^{PREGFC})$ is for the post-GFC. The determination of both long-run and short-run estimates follows the same approach as equation (1) except that the estimates for pre- and post-GFC are distinctly derived. Similarly,

D_t^{HIGHEC} is the dummy variable for high economic conditions which takes the value of one for positive values of economic conditions data and zero otherwise while $(1 - D_t^{HIGHEC})$ is for the low economic conditions. In other words, ϕ_{li}^{HIGHEC} and ϕ_{li}^{LOWEC} respectively denote the long-run estimates for the high and low economic conditions while γ_{li}^{HIGHEC} and γ_{li}^{LOWEC} are for their corresponding short-run estimates.

4.2 Model formulation for objective 2

For objective 2, the motive is to examine the impact of climate change on housing affordability using the same subcategories as in the first objective. Therefore, presented in equation 4 is the baseline model which connects housing affordability with climate change measured as temperature anomalies.

$$\Delta h_{it} = \rho_{4i} h_{i,t-1} + \alpha_{4i} + \phi_{4i} c_{i,t-1} + \sum_{j=1}^p \lambda_{4ij} \Delta h_{i,t-j} + \sum_{j=0}^q \gamma_{4ij} \Delta c_{i,t-j} + \mu_{4i} + \nu_{4it} \quad (4)$$

In addition to the previously defined variables like h , μ , and ν , we denote the climate change measure with c which is measured as temperature anomalies. The long-run impact of climate change on housing affordability is measured as $-\phi_{4i}/\rho_{4i}$ while γ_{4ij} measures the short-run impact. Like the first objective, there are two extended versions of equation (4) which involve the GFC and asymmetric weather conditions as reflected in equations (5) and (6) respectively:

$$\begin{aligned} \Delta h_{it} = & \rho_{5i} h_{i,t-1} + \alpha_{5i} + \phi_{5i}^{PREGFC} c_{i,t-1} * D_t^{PREGFC} + \phi_{5i}^{POSTGFC} c_{i,t-1} (1 - D_t^{PREGFC}) \\ & + \sum_{j=1}^p \lambda_{5ij} \Delta h_{i,t-j} + \sum_{j=0}^q \gamma_{5ij}^{PREGFC} \Delta c_{i,t-j} * D_t^{PREGFC} + \sum_{j=0}^q \gamma_{5ij}^{POSTGFC} \Delta c_{i,t-j} * (1 - D_t^{PREGFC}) + \mu_{5i} + \nu_{5it} \end{aligned} \quad (5)$$

$$\begin{aligned} \Delta h_{it} = & \rho_{6i} h_{i,t-1} + \alpha_{6i} + \phi_{6i}^{HIGHTE} c_{i,t-1} * D_t^{HIGHTE} + \phi_{6i}^{LOWTE} c_{i,t-1} (1 - D_t^{HIGHTE}) \\ & + \sum_{j=1}^p \lambda_{6ij} \Delta h_{i,t-j} + \sum_{j=0}^q \gamma_{6ij}^{HIGHTE} \Delta c_{i,t-j} * D_t^{HIGHTE} + \sum_{j=0}^q \gamma_{6ij}^{LOWTE} \Delta c_{i,t-j} * (1 - D_t^{HIGHTE}) + \mu_{6i} + \nu_{6it} \end{aligned} \quad (6)$$

We have previously defined the GFC dummy while the asymmetric weather conditions based on high and low temperature are defined by the dummy variables D_{it}^{HIGHTE} and $(1 - D_{it}^{HIGHTE})$

respectively. In the case of D_{it}^{HIGHTE} which is the dummy for high temperature, we assign one to positive values of temperature anomalies and zero otherwise while $(1 - D_{it}^{HIGHTE})$ is derived from the latter by design.

4.3 Model formulation for objective 3

Our third objective is to evaluate the role of interest rates in the housing affordability and economic conditions nexus, including during the global financial crisis and under different economic conditions. To begin with, the baseline model attempts to establish the connection between interest rate and housing affordability, while the extensions look at the role of GFC in the nexus and the mediating role of interest rate in the nexus between economic conditions and housing affordability. We formulate the three equations accordingly.

$$\Delta h_{it} = \rho_{7i} h_{i,t-1} + \alpha_{7i} + \phi_{7i} r_{i,t-1} + \sum_{j=1}^p \lambda_{7ij} \Delta h_{i,t-j} + \sum_{j=0}^q \gamma_{7ij} \Delta r_{i,t-j} + \mu_{7i} + \nu_{7it} \quad (7)$$

$$\begin{aligned} \Delta h_{it} = & \rho_{8i} h_{i,t-1} + \alpha_{8i} + \phi_{8i}^{PREGFC} r_{i,t-1} * D_t^{PREGFC} + \phi_{8i}^{POSTGFC} r_{i,t-1} (1 - D_t^{PREGFC}) \\ & + \sum_{j=1}^p \lambda_{8ij} \Delta h_{i,t-j} + \sum_{j=0}^q \gamma_{8ij}^{PREGFC} \Delta r_{i,t-j} * D_t^{PREGFC} + \sum_{j=0}^q \gamma_{8ij}^{POSTGFC} \Delta r_{i,t-j} * (1 - D_t^{PREGFC}) + \mu_{8i} + \nu_{8it} \end{aligned} \quad (8)$$

$$\begin{aligned} \Delta h_{it} = & \rho_{9i} h_{i,t-1} + \alpha_{9i} + \phi_{9i}^{HIGHEC} r_{i,t-1} * D_t^{HIGHEC} + \phi_{9i}^{LOWEC} r_{i,t-1} (1 - D_t^{HIGHEC}) \\ & + \sum_{j=1}^p \lambda_{9ij} \Delta h_{i,t-j} + \sum_{j=0}^q \gamma_{9ij}^{HIGHEC} \Delta r_{i,t-j} * D_t^{HIGHEC} + \sum_{j=0}^q \gamma_{9ij}^{LOWEC} \Delta r_{i,t-j} * (1 - D_t^{HIGHEC}) + \mu_{9i} + \nu_{9it} \end{aligned} \quad (9)$$

In equation (7), we are able to estimate the long-run and short-run impacts of interest rates on housing affordability. We also estimate in equation (8), the behaviour of interest rate between the pre-and post-GFC periods. And lastly, we test in equation (9) whether the role of interest rate in housing affordability differs during high and low economic conditions. We have previously defined all the dummy variables except for the fact we are now intersecting them with interest rates.

5. Results and Discussion

In accordance with our methodological framework, we present and discuss our empirical results in a chronological manner, aligning them with our three specific objectives and the various scenarios considered. Our empirical estimates and findings have been meticulously analyzed for each objective across three distinct scenarios. In the first scenario, we assume a uniform temperature throughout all 50 federated units studied in the U.S. In the second and third scenarios, we categorize the states into those with high temperatures (the hottest regions) and those with low temperatures (the coldest regions). Consequently, the long-run and short-run empirical estimates presented in Tables 3, 4, and 5 in Sections 5.1, 5.2, and 5.3 effectively address our three objectives under these alternative scenarios. These tables not only highlight the comparative effects of the pre-global financial crisis (pre-GFC) and post-global financial crisis (post-GFC) periods but also elucidate the different economic conditions within each nexus. This thorough analysis is essential for drawing meaningful conclusions and implications.

5.1 Economic Conditions and housing affordability under different scenarios

Table 3 illustrates that, when analyzing the entire sample, stronger economic conditions are associated with better housing affordability, at least in the short term. The consistent statistical reliability of this finding across the various scenarios examined supports our hypothesis that improved economic conditions can enhance housing affordability. It is important to note that housing affordability is calculated as the ratio of housing price to income; as such, higher income due to improved economic conditions reduces the proportion of housing price and/or rent in an individual's budget. Hence, a lower price-to-income ratio would imply better affordability, and a higher ratio would indicate less affordability. While the relationship between housing affordability and economic condition is positive in the long run, the latter's impact on the former is rather insignificant. However, the implication of the short-run impact suggests that as the economic condition improves in the entire state, the household's ability to afford more housing units becomes more enhanced (that is, as the economic condition improves by, say, one unit, housing becomes more affordable by 0.75 per cent). This aligns well with our hypothesis and with the idea that improved economic conditions often constitute a strong mechanism by which rising housing costs can be easily suppressed (see Anthony, 2022).

Further evidence becomes entrenched when the emergence of the global financial crisis is considered. While the long-run impact of both pre-GFC and post-GFC does not count in the nexus, the short-run impact significantly suggests better housing affordability instead of current economic conditions irrespective of the presence or otherwise of the global financial crisis. The short-lived impact is likely to arise from policy measures (see also Wetzstein, 2021) and weather conditions that the region is subjected to. In any such situation, the global financial crisis has some role in the connection. In our third analysis, state-level economic condition is partitioned into high (improved) and low (depressed) economic conditions, and they are investigated to know their distinct impact on housing affordability. High and low economic conditions improve housing affordability both in the short- and long-run periods, albeit the impact is only reinforced for the low conditions in the latter period. This implies that the low economic condition will have a long-lived impact on housing affordability than otherwise. Expectedly, during the economic tumult, economic activities often suffer great setbacks with much concern about household income. As suggested in this study, the asymmetric impact points to the fact that an economic downturn has higher implications for housing affordability while the opposite might signal less consequence. During an economic downturn, demands are generally low, forcing prices down. Thus, low demand for housing when the economy slows down could portend a reduction in housing prices and, by extension, better affordability. The study by Garriga et al. (2021) has further attributed this setback to investor activities.

We further categorize the states into the hottest and coldest regions, and in this case, the results become more evident for the two categories (see Table 3). For the hottest region, the short-run implication is more imminent for the full sample, pre-GFC and post-GFC as well as across the high (improved) and low (depressed) economic conditions. By extension, just like in the case when all states are considered, economic conditions strengthen the ability of households concerning the affordability of houses. However, this is only held for the short-run period. The long-run implication could be more effective. The result for the coldest state is rather different. In contrast, low economic conditions mitigate housing affordability in both long and short-run periods for full sample analysis (with higher magnitude in the long run than in the short run and the periods, before and after GFC, only in the short-run period of the former (pre-GFC) we could not establish enough evidence for the implication of economic condition for housing affordability. It thus becomes

suggestive that weather condition matters in this nexus. When the economic condition is partitioned into high and low classifications, both conditions improve housing affordability in both short-run and long-run situations. However, the improvement is more pronounced for low economic conditions. Thus, regardless of the prevailing weather condition (hot or cold) in the United States, the low economic condition improves housing affordability significantly. This buttresses our previous argument that low demand during the economic downturn has a reversal implication for housing prices and, thus, better affordability.

Table 3: Economic conditions and housing affordability under three (3) scenarios (for the 50 U.S. hottest and coldest states)

Parameter	Scenario 1: 50 U.S state			Scenario 2 U.S states with high temperature [Hottest Region]			Scenario 2: U.S states with low temperature [Coldest Region]		
	Full Sample	Pre-GFC	High Econ	Full Sample	Pre-GFC	High Econ	Full Sample	Pre-GFC	High Econ
		Vs Post-GFC	Vs Low Econ		Vs Post-GFC	Vs Low Econ		Vs Post-GFC	Vs Low Econ
<i>Empirical estimates based on equation 1</i>									
ϕ_{1i}	3.499 (4.747)			7.893 (8.580)			-0.815*** (0.285)		
γ_{1ij}	-0.0075*** (0.000605)			-0.00638*** (0.000891)			-0.00719*** (0.00113)		
<i>Empirical estimates based on equation 2</i>									
ϕ_{2i}^{PREGFC}		-4.622 (3.744)			-7.308 (6.782)			-1.138** (0.491)	
$\phi_{2i}^{POSTGFC}$		-4.837 (3.395)			-6.942 (6.136)			-1.726** (0.857)	
γ_{2ij}^{PREGFC}		-0.0059*** (0.00151)			-0.00570*** (0.00206)			-0.000721 (0.00390)	
$\gamma_{2ij}^{POSTGFC}$		-0.0088*** (0.000744)			-0.00774*** (0.00112)			-0.0101*** (0.000905)	
<i>Empirical estimates based on equation 3</i>									
ϕ_{3i}^{HIGHEC}			-0.279 (1.188)			-0.00203 (1.068)			-0.867 (2.433)
ϕ_{3i}^{LOWEC}			-0.602** (0.279)			-0.160 (0.242)			-0.956** (0.423)
γ_{3ij}^{HIGHEC}			-0.0109*** (0.00210)			-0.00972*** (0.00316)			-0.00557 (0.00526)
γ_{3ij}^{LOWEC}			-0.00519*** (0.000982)			-0.00388*** (0.00114)			-0.00772*** (0.00173)
Observations	1,715	1,715	1,715	945	945	945	769	769	769

Source: Author's own work

Note: The parameters ϕ and γ captures the long-run and short-run estimates in each of the equations and across the different scenarios considered.

The values in parentheses are the standard error while ***, **, and * denoting significant at 1%, 5% and 10% levels of significance.

5.2 Climate Change and housing affordability under different scenarios

In relation to the second objective, the empirical estimates displayed in Table 4 illustrate the impact of climate change on housing affordability. The negative and statistically significant short-run parameters across all considered scenarios suggest that climate change tends to improve housing affordability. For example, in areas that are becoming more prone to extreme weather events or have seen a decline in natural resources, housing demand may decrease, potentially lowering prices. Additionally, as people begin to seek more sustainable living environments, there could be a shift in demand away from certain locations, which might make housing more affordable in those areas. This conclusion holds true regardless of whether a state is situated in the hottest or coldest region, offering valuable insights for policymakers and stakeholders. Reinforcing our previous results on the cold regions when considering economic condition as the predictor variable, our results show better housing affordability in the states with relatively cold weather. This aligns with the assertion that houses sell faster during the hot season⁸, and by implication, higher prices and lower affordability during this season. Subjecting this nexus to further scrutiny by exploring the role of both calm and turbulent periods, as indicated by the periods before and after the global financial crisis, our results reveal that in the short run, climate change improves housing affordability across all the state classifications save states with hot weather prior to the global crisis.

When the climate change impact is categorized into a high and low temperature, our results – across the 50 U.S. states – suggest better housing affordability during short- and long-run periods, although with significant mixed influence. While low temperatures due to climate change imply better housing affordability in the long run, the impact becomes negligible in the short run. On the contrary, the significance of high temperature is negligible in the long run, while it is pronounced in the short run. Similar results are also obtained for hot region states. For states with cold weather, both high and low temperature from climate change make housing affordability better in the short run. However, this influence is upturned in the long-run period. In other words, while low and high temperature from climate change enhances housing affordability in the cold states during the short-run period, climate change (both low and high temperature) worsens affordability in the long-run. Due to harsh weather conditions, the construction of more houses might be somewhat affected,

⁸ <https://www.a-pp.co.uk/blogs-how-weather-affects-house-prices/>

and the aftermath can result in a housing crisis. After highlighting this possibility, Fu (2022) further calls for quick action to address it. A more significant implication is found when the temperature is very high in any of the states under consideration. The short-run implication here explains the possible policy that is regularly put in place by the U.S. government to checkmate the impact of climate change on the economy. The possibility of this policy impact extending beyond short-run periods should be of utmost priority to the U.S. In the McDiarmid (2020) study, the possibility that climate change can cause rising housing prices was linked to the requirement for decarbonization during the building process. Essentially, it is expected that the impact of climate change in this regard will be crucial for the potential house owner, which may have a lasting impact on housing commodities, especially for the renters.

Table 4: Climate change and housing affordability under three (3) scenarios (for the 50 U.S. hottest and coldest states)

Parameter	Scenario 1: 50 U.S state			Scenario 2 U.S states with high temperature [Hottest Region]			Scenario 2: U.S states with low temperature [Coldest Region]		
	Full Sample	Pre-GFC	High Econ	Full Sample	Pre-GFC	High Econ	Full Sample	Pre-GFC	High Econ
		Vs Post-GFC	Vs Low Econ		Vs Post-GFC	Vs Low Econ		Vs Post-GFC	Vs Low Econ
<i>Empirical estimates based on equation 4</i>									
ϕ_{4i}	0.292 (0.318)			0.541 (0.522)			-2.687 (2.890)		
γ_{4ij}	-0.0074*** (0.00128)			-0.00687*** (0.00187)			-0.00859*** (0.00163)		
<i>Empirical estimates based on equation 5</i>									
ϕ_{5i}^{PREGFC}		0.0366 (0.492)			0.0690 (0.879)			0.404 (0.332)	
$\phi_{5i}^{POSTGFC}$		0.187 (0.322)			0.425 (0.534)			0.192 (0.412)	
γ_{5ij}^{PREGFC}		-0.0037*** (0.00122)			-0.00263 (0.00180)			-0.0053*** (0.00152)	
$\gamma_{5ij}^{POSTGFC}$		-0.0125*** (0.00150)			-0.0132*** (0.00217)			-0.0124*** (0.00200)	
<i>Empirical estimates based on equation 6</i>									
ϕ_{6i}^{HIGHTE}			-0.125 (0.500)			-0.421 (0.601)			0.0445 (0.939)
ϕ_{6i}^{LOWTE}			-21.13* (11.55)			-34.79* (18.97)			8.237 (12.40)
γ_{6ij}^{HIGHTE}			-0.00860*** (0.00157)			-0.00760*** (0.00219)			-0.00995*** (0.00217)
γ_{6ij}^{LOWTE}			-0.00885 (0.0181)			-0.00265 (0.0301)			-0.0195 (0.0190)
Observations	1,715	1,715	1,715	945	945	945	769	769	769

Source: Author's own work

Note: The parameters ϕ and γ captures the long-run and short-run estimates in each of the equations and across the different scenarios considered.

The values in parentheses are the standard error while ***, **, and * denoting significant at 1%, 5% and 10% levels of significance.

5.3 The mediating role of interest rate

As indicated in Table 5, the mediating role of interest rate is evaluated concerning the nexus between economic conditions and housing affordability. The result adduces the implication of interest rate to long-run phenomenon irrespective of whether a state is grouped as hottest or coldest region. In other words, introducing interest rates into the model and analyzing the connection between economic conditions and housing affordability produces striking results. Essentially, interest rate mitigates/upturns the outcomes of the long-run component of the nexus. As against the nexus/results reported for the long run in the model without interest, housing affordability (defined as price-to-income) becomes more affordable in the presence of interest rates. The foregoing is also obtainable during the pre-GFC era. Further partitioning the predictor variable (economic conditions) into high and low conditions also confirms these results. These results imply that it will take a longer period for credit availability, for instance, to have a reversing impact on housing prices since investment in construction takes a long period. In this connection, Trimbath and Montoya (2002) technically suggest that interest rate movement will affect housing affordability differently. Particularly, the period where the interest rate is very low with relatively higher growth in income can generate some level of reduction in housing prices.

Table 5: The mediating role of interest rate under three (3) scenarios (for the 50 U.S. hottest and coldest states)

Parameter	Scenario 1: 50 U.S state			Scenario 2 U.S states with high temperature [Hottest Region]			Scenario 2: U.S states with low temperature [Coldest Region]		
	Full Sample	Pre-GFC Vs Post-GFC	High Econ Vs Low Econ	Full Sample	Pre-GFC Vs Post-GFC	High Econ Vs Low Econ	Full Sample	Pre-GFC Vs Post-GFC	High Econ Vs Low Econ
<i>Empirical estimates based on equation 7</i>									
ϕ_{7i}	-0.281 (0.225)			-0.0934 (0.0683)			-0.715 (0.711)		
γ_{7ij}	0.0136*** (0.00118)			0.0144*** (0.00202)			0.0128*** (0.00108)		
<i>Empirical estimates based on equation 8</i>									
ϕ_{8i}^{PREGFC}		-0.0354 (0.0387)			-0.0447 (0.0274)			-0.0542 (0.0775)	
$\phi_{8i}^{POSTGFC}$		0.459** (0.213)			0.557*** (0.183)			0.340 (0.422)	
γ_{8ij}^{PREGFC}		0.0111*** (0.00106)			0.0119*** (0.00180)			0.0106*** (0.00121)	
$\gamma_{8ij}^{POSTGFC}$		0.0262*** (0.00191)			0.0275*** (0.00325)			0.0245*** (0.00165)	
<i>Empirical estimates based on equation 9</i>									
ϕ_{9i}^{HIGHEC}			-0.153*** (0.0479)			-0.181*** (0.0563)			-0.105 (0.0821)
ϕ_{9i}^{LOWEC}			-0.0672 (0.202)			-0.106 (0.133)			0.191 (0.462)
γ_{9ij}^{HIGHEC}			0.0131*** (0.00134)			0.0151*** (0.00208)			0.0101*** (0.00166)
γ_{9ij}^{LOWEC}			0.0154*** (0.00149)			0.0163*** (0.00255)			0.0135*** (0.00134)
Observations	1,715	1,715	1,715	945	945	945	769	769	769

Source: Author's own work

Note: The parameters ϕ and γ captures the long-run and short-run estimates in each of the equations and across the different scenarios considered.

The values in parentheses are the standard error while ***, **, and * denoting significant at 1%, 5% and 10% levels of significance.

5. Conclusion

Housing costs have been rising at a rate that surpasses income growth, leading to a significant affordability crisis. The availability of housing that meets varying affordability needs is closely linked to the economic conditions faced by individuals and the nation. This situation has prompted increased efforts to investigate the vital relationship between housing affordability and economic factors (see, for example, Wetzstein, 2017; Meen & Whitehead, 2020; Lee et al., 2022). However, it is essential to recognize that housing affordability is influenced not only by economic conditions but also by the location and climate of a property. Research indicates that properties in flood-prone areas should significantly depreciate compared to those in safer regions. This price decrease is anticipated to align with the present value of all expected flood insurance premiums. In other words, extreme weather events and environmental risks can substantially lower housing quality, resulting in diminished demand and subsequent price reductions for properties in vulnerable areas. Studies such as those by Wetzstein (2017) and Bezgrebelna et al. (2021) have highlighted the alarming effects of climate change on housing values. Furthermore, in the aftermath of the 2008 subprime mortgage crisis, compelling evidence has emerged linking interest rates—a monetary policy anchor—to mortgage rates and, by extension, housing affordability. This complex interplay of factors underscores the urgent need for policymakers to adopt a comprehensive approach to address housing affordability, considering both economic conditions and environmental challenges that shape our living spaces.

However, while the review of existing works shows that the effect of each of these fundamentals on housing affordability has been investigated separately, one of the main contributions of this study to the literature is the hypothesis of the mediating role of interest rate in the effect of economic condition on housing affordability. Additionally, we hypothesized that such a mediating role of interest rate depends on whether a state has a high (improved) or low (depressed) economic condition. We further complement the literature with some possible scenarios, such as the possibility of the effect of climate change on housing affordability being sensitive to whether a state is in the region of high temperature (hottest region) or low temperature (coldest region). Methodologically, we employ the Panel ARDL model for the estimation procedure. This technique comes in handy while examining the dynamic relationship among variables, as it also accounts for both short and long-run estimates and potential heterogeneity in the estimated nexus. We partition

the periods into pre-GFC and post-GFC to have a robust analysis. This is done to identify possible deferring implications inherent in the given bounds.

Empirically, our research sheds light on vital insights regarding housing affordability as influenced by economic conditions and climate change, which warrant careful consideration. Our findings indicate that improved economic conditions significantly enhance housing affordability across various states. However, this effect tends to be short-lived, except in colder regions where it tends to endure longer. This may not be unconnected to the fact that with rising incomes, more people are able to afford homes, which can stabilize or reduce housing prices relative to income. In colder regions, where housing demand might be affected by weather factors, improved economic conditions can make these areas more attractive, further contributing to affordability. We confirm that favorable economic conditions positively impact housing affordability in both scenarios by analyzing data from the periods before and after the global financial crisis (GFC). However, the influence is powerful in the short term for most states, apart from those in colder climates. Additionally, our examination of low economic conditions demonstrates a consistent improvement in affordability in the short and long term across all states, including colder regions. While beneficial economic conditions are associated with increased affordability, this relationship is predominantly observable in the short run. When we consider climate change, our findings reveal further enhancements in housing affordability across various states and specific sub-groups, especially in the hottest and coldest regions, although these improvements are temporary. Similarly, when categorizing climate based on temperature extremes, we observe that housing affordability improves in both short- and long-term contexts, though the significance of these findings varies.

Our comprehensive analysis of the mediating role of interest rates underscores their significance in connecting economic conditions to housing affordability. The evidence indicates that interest rates have a substantial impact on housing affordability across all classifications in the long term. Strengthening favorable interest rates can notably enhance housing affordability over time. This relationship is crucial for policymakers who seek to establish sustainable housing solutions. For example, policymakers can more effectively navigate the interactions between interest rates, climate change, and housing affordability, ultimately fostering more sustainable and resilient communities. Strategies could include offering lower interest rates for financing sustainable

housing or retrofitting existing buildings to better withstand climate impacts. Such measures could encourage investment in more resilient communities and help mitigate the financial risks associated with climate change.

References

- Adams, Z., & Füss, R. (2010). Macroeconomic determinants of international housing markets. *Journal of Housing Economics*, 19(1), 38-50.
- Agnello, L., & Schuknecht, L. (2011). Booms and busts in housing markets: Determinants and implications. *Journal of Housing Economics*, 20(3), 171-190.
- Aliyev, K., Amiraslanova, M., Bakirova, N., & Eynizada, N. (2019). Determinants of housing prices in Baku: empirical analyses. *International Journal of Housing Markets and Analysis*, 12(2), 281-297.
- Anthony, J. (2018). Economic prosperity and housing affordability in the United States: Lessons from the booming 1990s. *Housing Policy Debate*, 28(3), 325-341.
- Anthony, J. (2022). Housing affordability and economic growth. *Housing Policy Debate*, 1-19.
- Apergis, N. (2020). Natural disasters and housing prices: Fresh evidence from a global country sample. *International Real Estate Review*, 23(2), 189 – 210.
- Badarinza, C., Campbell, J. Y., & Ramadorai, T. (2018). What calls to ARMs? International evidence on interest rates and the choice of adjustable-rate mortgages. *Management Science*, 64(5), 2275-2288.
- Baldauf, M., Garlappi, L., & Yannelis, C. (2020). Does climate change affect real estate prices? Only if you believe in it. *The Review of Financial Studies*, 33(3), 1256–1295.
- Bernanke, B. (2010). Monetary Policy and the Housing Bubble. Keynote Speech, American Economic Association Annual Meeting.
- Bernstein, A., M. Gustafson, and R. Lewis. 2018. Disaster on the horizon: The price effect of sea level rise. Working Paper, University of Boulder, Colorado
- Bernstein, A., Gustafson, M. and Lewis, R. (2019). Disaster on the horizon: The price effect of sea level rise. *Journal of Financial Economics*, 134, 253-272.
- Baumeister, C., Leiva-León, D., & Sims, E. (2021). Tracking weekly state-level economic conditions. *Review of Economics and Statistics*, 1-45.
- Bjørnland, H. C., & Jacobsen, D. H. (2010). The role of house prices in the monetary policy transmission mechanism in small open economies. *Journal of financial stability*, 6(4), 218-229.
- Bin, O., & Landry, C.E. (2013). Changes in implicit floor risk premiums: Empirical evidence from the housing market. *Journal of Environmental Economics and Management*, 65, 361-376.
- Boustan, L.P., Kahn, M.E., Rhode, P.W., & Yanguas, M.L. (2017). The Effect of Natural Disasters on Economic Activity in US Counties: A Century of Data. NBER Working Paper, No. 23410, National Bureau of Economic Research, Inc.
- Breitung, J. (2000). The local power of some unit root tests for panel data. *Advances in Econometrics*, 15, 161-177. [http://dx.doi.org/10.1016/S0731-9053\(00\)15006-6](http://dx.doi.org/10.1016/S0731-9053(00)15006-6)
- Cohen, V., & Karpavičiūtė, L. (2017). The analysis of the determinants of housing prices. *Independent journal of management & production*, 8(1), 049-063.
- Cooper, D.H., Luengo-Prado, M. J., & P.Olivei, G. (2016). Monetary Policy and Regional House-Price Appreciation. Working Papers 16-18, Federal Reserve Bank of Boston.

- D'Acunto, F., & Rossi, A.G. (2017). Regressive Mortgage Credit Redistribution in the Post-Crisis Era. Working Paper, University of Maryland.
- Dokko, J., Doyle, B.M., Kiley, M.T., Kim, J., Sherlund, S., Sim, J., & Van Den Heuvel, S. (2011). Monetary policy and the global housing bubble. *Economic Policy* 26(66), 237–287.
- Demary, M. (2010). The interplay between output, inflation, interest rates and house prices: international evidence. *Journal of Property Research*, 27(1).
<https://doi.org/10.1080/09599916.2010.499015>
- De Wit, E. R., Englund, P., & Francke, M. K. (2013). Price and transaction volume in the Dutch housing market. *Regional Science and Urban Economics*, 43(2), 220-241.
- Di Maggio, M., Kermani, A., Keys, B. J., Piskorski, T., Ramcharan, R., Seru, A., & Yao, V. (2017). Interest rate pass-through: Mortgage rates, household consumption, and voluntary deleveraging. *American Economic Review*, 107(11), 3550-3588.
- Egert, B., & Mihaljek, D. (2007). Determinants of house prices in central and eastern Europe. *Comparative Economic Studies*, 49, 367–388.
- Fadiga, M. L., & Wang, Y. (2009). A multivariate unobserved component analysis of the U.S. housing market. *Journal of Economics and Finance*, 33, 13-26.
- Fu, S. (2022). How Cities Can Tackle Both the Affordable Housing and Climate Crises. Retrieved from <https://housingmatters.urban.org/articles/how-cities-can-tackle-both-affordable-housing-and-climate-crises#>
- Gao, Z., Sockin, M., & Xiong, W. (2020). Economic consequences of housing speculation. *The Review of Financial Studies*, 33(11), 5248-5287.
- Garriga, C., Gete, P., & Tsouderou, A. (2020). *Investors and housing affordability*. Federal Reserve Bank of St. Louis, Research Division.
- Garriga, C., Hedlund, A., Tang, Y., & Wang, P. (2021). Rural-urban migration and house prices in China. *Regional Science and Urban Economics*, 91, 103613.
<https://doi.org/10.1016/j.regsciurbeco.2020.103613>
- Gibson, M., Mullins, J. T., & Hill, A. (2018). Climate change, flood risk, and property values: Evidence from New York City. Working Paper.
- Harrison, D., T. Smersh, G., & Schwartz, A. (2001). Environmental determinants of housing prices: the impact of flood zone status. *Journal of Real Estate Research*, 21(1-2), 3-20.
- Harris, R.D.F., & Tzavalis, E. (1999). Inference for unit roots in dynamic panels where the time dimension is fixed. *Journal of Econometrics*, 91, 201-226. [https://doi.org/10.1016/S0304-4076\(98\)00076-1](https://doi.org/10.1016/S0304-4076(98)00076-1)
- Im, K.S., Pesaran, M.H. & Shin, Y. (1997). Testing for Unit Roots in Heterogeneous Panels. Department of Applied Economics, University of Cambridge, Cambridge.
- Jappelli, T., & Scognamiglio, A. (2018). Interest rate changes, mortgages, and consumption: evidence from Italy. *Economic Policy*, 33(94), 183-224.
- Justiniano, A., Primiceri, G. E., & Tambalotti, A. (2019). Credit supply and the housing boom. *Journal of Political Economy*, 127(3), 1317-1350.
- Karpestam, P., & Johansson, S. (2019). Interest-only mortgages and housing market fluctuations in Denmark. *Journal of Housing Economics*, 46, 101627.
- Keys, B. J., Piskorski, T., Seru, A., & Yao, V. (2014). *Mortgage rates, household balance sheets, and the real economy* (No. w20561). National Bureau of Economic Research.
- Kuttner, K. N. (2013). Low Interest Rates and Housing Bubbles: Still No Smoking Gun. In: *The Role of Central Banks in Financial Stability*, 159–185.

- Levin, A., Lin, C.F. & Chu, C.S.J. (2002) Unit Root Tests in panel Data: Asymptotic and Finite-Sample Properties. *Journal of Econometrics*, 108, 1-24. [https://doi.org/10.1016/S0304-4076\(01\)00098-7](https://doi.org/10.1016/S0304-4076(01)00098-7)
- Luciani, M. (2015). Monetary policy and the housing market: A structural factor analysis. *Journal of Applied Econometrics*, 30(2), 199–218.
- McDiarmid, H. (2020). Climate change and housing affordability in Canada, Accessed through: https://www.mcdiarmidclimateconsulting.ca/uploads/1/3/0/1/130157067/climate_change_and_housing_affordability_in_waterloo_region.pdf
- McDonald, J. & Stokes, H. (2013). Monetary policy and the housing bubble. *The Journal of Real Estate Finance and Economics*, 46(3), 437–451.
- McDonald, J., & Stokes, H. (2015). Monetary policy, fiscal policy, and the housing bubble. *Modern Economy* 06, 165–178.
- McPherson, M. (2019). Minneapolis has officially eliminated single-family zoning. Inman. Retrieved from <https://www.inman.com/2019/10/25/minneapolis-has-officially-eliminated-single-family-zoning/>
- McQuinn, K., & O'Reilly, G. (2008). Assessing the role of income and interest rates in determining house prices. *Economic modelling*, 25(3), 377-390.
- Meen, G., & Whitehead, C. (2021). What Factors Determine Changes in House Prices and Rents? Understanding Affordability: The Economics of Housing Markets (Bristol, 2020; online edn.), <https://doi.org/10.1332/policypress/9781529211863.003.0003>, accessed 9 Nov. 2024
- Murfin, J. & Spiegel, M. (2018). Is the risk of sea level rise capitalized in residential real estate? *The Review of Financial Studies*, 33(3), 1217–1255.
- Mian, A., & Sufi, A. (2009). The consequences of mortgage credit expansion: evidence from the US mortgage default crisis. *The Quarterly Journal of Economics*, 124 (4), 1449–1496.
- Mian, A., & Sufi, A. (2010). Household leverage and the recession of 2007–09. *IMF Economic Review*, 58 (1), 74–117.
- Pesaran, M.H., & Smith, R. (1995). Estimating long-run relationships from dynamic heterogeneous panels. *Journal of Econometrics*, 68, 1, 79-113. [https://doi.org/10.1016/0304-4076\(94\)01644-F](https://doi.org/10.1016/0304-4076(94)01644-F)
- Pesaran, M.H., Shin, Y., & Smith, R.P. (1997) Pooled Estimation of Long-Run Relationships in Dynamic Heterogeneous Panels. University of Cambridge, Department of Applied Economics, Cambridge
- Rehman, M.U., Ali, S., & Shahzad, S.J.H. (2020). Asymmetric nonlinear impact of oil prices and inflation on residential property prices: A case of US, UK and Canada. *The Journal of Real Estate Finance and Economics*, 61, 39–54.
- Schweitzer, A. (2019). Without more housing soon, leaders fear declining quality of life. Retrieved from <https://wamu.org/story/without-more-housing-soon-leaders-fear-declining-quality-of-life/>
- Shin, Y., Yu, B., & Greenwood-Nimmo, M. (2014). Modelling asymmetric cointegration and dynamic multipliers in a nonlinear ARDL framework. *Festschrift in honour of Peter Schmidt: Econometric methods and applications*, 281-314.
- Trimbath, S., & Montoya, J. (2002). Housing affordability in three dimensions: Price, income and interest rates. *Milken Institute Policy Brief*, (31).

- Tripathi, S. (2019). Macroeconomic Determinants of Housing Prices: A Cross Country Level Analysis. Available at: https://mpa.ub.uni-muenchen.de/98089/1/MPRA_paper_98089.pdf.
- Vaidynathan, D., Kayal, P., & Maiti, M. (2023). Effects of economic factors on median list and selling prices in the U.S housing market. *Data Science and Management*, 6, 199–207.
- Wetzstein, S. (2021). Assessing post-GFC housing affordability interventions: A qualitative exploration across five international cities. *International journal of housing policy*, 21(1), 70-102.
- Wetzstein, S. (2017). The global urban housing affordability crisis. *Urban Studies*, 54(14), 3159-3177. <https://doi.org/10.1177/0042098017711649>
- Zhang, Y., Hua, X., & Zhao, L. (2012). Exploring determinants of housing prices: A case study of the Chinese experience in 1999–2010. *Economic modelling*, 29(6), 2349-2361.