Unveiling the Dynamics of Inflation in Housing Rent

by
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Submitted to the Center for Real Estate in partial fulfillment of the requirements for the degree(s) of
Master of Science in Real Estate Development
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ABSTRACT

Inflation is one of today's biggest short-term global economic challenges, and housing costs, a persistent component of inflation whose price increases have had a strong influence in the loss of purchasing power of American households, and which is irreplaceable, have more than doubled in the past 20 years. Housing cost rises have outpaced inflation for the rest of the products typically consumed by individuals, and low-income earners have been highly burdened by the situation. However, this has not always been the tendency, and this paper will explain how the recent rise in rents can be mainly attributed to a higher demand for housing, as opposed to higher construction and operating costs due to inflation spillovers into real estate related products. This will be demonstrated through both qualitative and quantitative analyses of the housing market and its price dynamics in the United States.

The first section of this document — *The Upheaval of Housing Costs* — will explain how rising house prices have trespassed into rising residential rents, and how this has been highly influenced by long periods of expansionary monetary policy and the implementation of Quantitative Easing, along with rising income inequality and the failure of the market to swiftly adapt its residential products to the changing dynamics in demand. This chapter offers a well-rounded explanation of the demand determinants of housing, as well as historical context to better understand why rents have outpaced inflation for other products since the 1980's.

The second section — *Rents, House Prices, and Inflation* —exhibits a quantitative analysis of how house prices and inflation for non-rent products impact residential rents. This analysis was carried out with an *Error Correction Model* to capture both the short-term and long dynamics of these variables, given that changes in house prices and inflation do not fully impact rents immediately. This model was run for the United States and replicated for Boston, Chicago, Dallas, Detroit, Houston, Los Angeles, Miami, New York, Philadelphia, and San Francisco. Results for this analysis show that since 1978, *demand-pull inflation has dominated rent growth* in the United States and in most of the studied cities. This analysis is followed by an *Appendix* showcasing the detailed outputs for every model, as well as graphs to visually support our quantitative analysis and provide comprehensive evidence of the dynamics of these variables in those cities.

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THE UPHEAVAL OF HOUSING COSTS

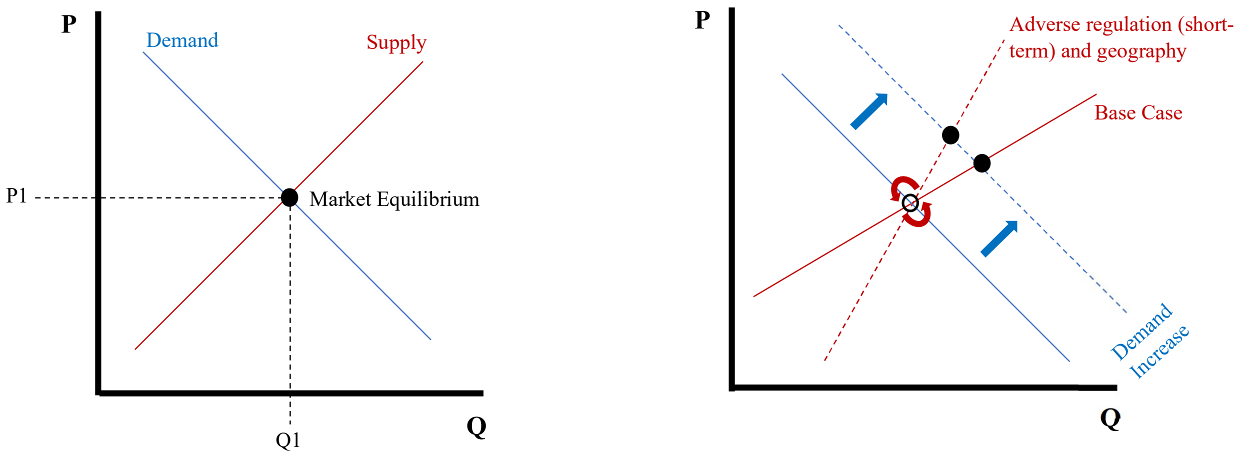
It is no secret that the United States is facing a big challenge when it comes to housing costs, which have not been worse by affordability standards in almost 40 years. Some argue that this is the product of low housing supply driven by the pandemic, others might say that high interest rates are inflating mortgage payments and making it harder to afford a home. This chapter will show that the situation started to unfold before that, with rising income inequality, and that it was exacerbated by economic policies that have continuously attempted to mitigate the consequences of a mistake by financial institutions in the late 1990's that led us to the Great Recession and raised threats of deflation in the United States, forcing Central Banks to experiment with bold expansionary policies. This chapter is not an opinion on the Fed's response to recent economic challenges, but rather an analysis of how monetary policy has played an important role in today's housing affordability problem, and of course, how these effects have been accentuated by circumstantial challenges, such as the COVID-19 pandemic.

Before we get into that, it is important to understand the relationship between monetary policy and housing economics. We will cut straight to the focus of this paper; the price of housing — be it rent or the purchase of a home — which is determined by the same two characteristics that drive the price of anything in a market economy; supply and demand. The supply of new housing in any given area will be primarily dictated by construction costs, land availability, and regulations. The more adverse these characteristics, the higher the limitations of new housing supply entering the market and the higher their price sensitivity to demand booms (see *Figure 1*). Most of these conditions rarely change within a city, but demand for housing on the other hand, is very dynamic. Population growth, household income, employment, and interest rates are never static. These are highly influenced by the business cycle and the central bank's monetary policy. These are some of the forces that have recently increased the flow of capital into the housing market and have driven prices to rise considerably.

To apply these forces upon a market and influence its demand, Central Banks apply monetary policy through various tools with different implications. Pulling or loosening on each of these strings will catalyze or depress business activity — each with different side-effects — with the goal of maximizing employment and stabilizing inflation. In the United States, these tools usually include (i) the purchase and sale of government securities in the open market to influence the country's money supply, known as *Open Market Operations*; (ii) changing the rate that the Federal Reserve charges for short-term loans to depository institutions, known as the *Discount Rate,* to influence market interest rates; and

(iii) defining *Reserve Requirements* that banks must hold against specified deposit liabilities. It is important to note that in housing economics, monetary policy impacts demand, but also influences supply by facilitating or complicating new construction at various development and operating costs. We will dive deeper into this shortly.

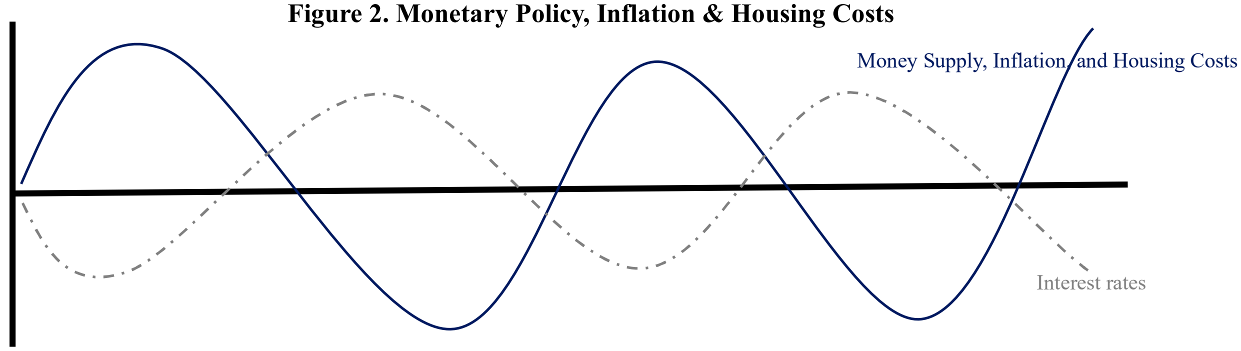
Figure 1. Interaction of Supply and Demand in Housing



Let's focus on demand first, and specifically on how it is impacted by interest rates. When the Fed lowers the discount rate and increases money supply, it steers the market into charging lower interest rates, making mortgage loans more accessible. As an example, a 30-year loan at 8.0% for a $300,000 mortgage would demand a constant monthly payment of $2,220. Would rates decrease to 3.0%, a household willing to pay the same amount can now afford a $522,000 loan, and therefore, a much more expensive home. However, long periods of expansionary monetary policy — as this is commonly known — will increase business activity, and eventually prices for several products will rise at an uneven and uncomfortable pace for households. If inflation for these products is not controlled, it can cause severe complications for households, businesses, and therefore for the overall economy. Hence, the Fed will be forced to eventually reverse their actions to control prices; they will reduce money supply and increase the discount rate, which will steer the market towards higher interest rates and lower borrowing capacity, causing less business activity, lower inflation rates, lower growth in house prices, and consequently, lower rent growth too (see *Figure 2*).

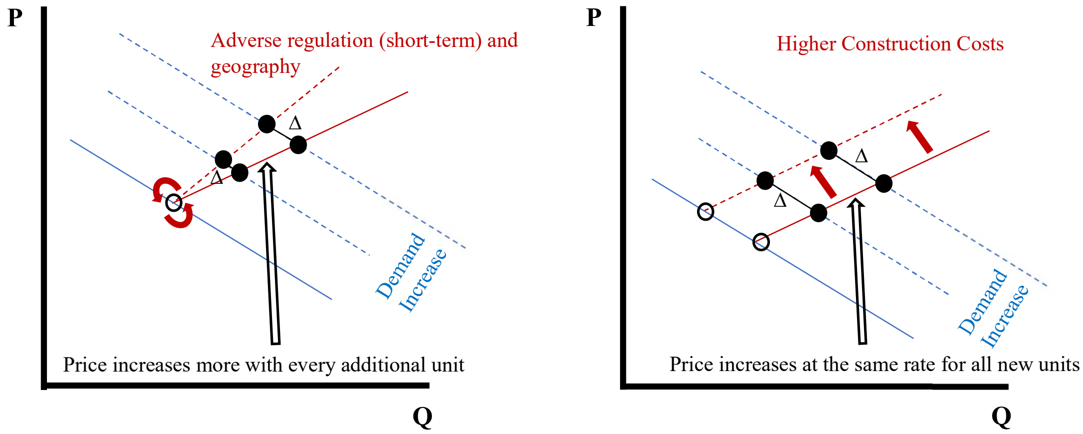
If we think about housing from a financial standpoint, owning is not so different from renting. Owning is just an upfront investment to avoid future rental payments. So, if this investment becomes expensive enough in relation to renting and therefore unreasonable, homeowners will sell their houses and rent instead. However, it is not only the monthly cost of homeownership that affects the rental market. An interesting finding in this paper is how the total price of houses for sale, regardless of the monthly costs required to afford it, do too. This could be explained in part by the caps on mortgages, which are usually set at 80% of the home's value. This leaves a significant amount of equity to be covered by the buyer, limiting the number of households who can afford to invest in a house regardless of the monthly costs, and pushing potential homebuyers into the rental market too. With these considerations in mind, an increased willingness from households to spend more on monthly mortgage costs; or an increase in house values due to lower interest rates; will both force potential homebuyers into the rental market and increase rents until prices for owning and renting fall to an equilibrium. Changes in prices flow in this direction because since the 1960's, around two thirds of the population in the United States owns their home. An insignificant decrease in the pool of homeowners could significantly increase the renter's pool due to the size difference of both groups, which explains the dominance of the homeownership market.

Figure 2. Monetary Policy, Inflation & Housing Costs



The last piece for understanding house prices is on the supply side. Even though all the supply determinants are relevant for this matter, the most dynamic and the most pertinent one for this paper is the cost of construction and operation of housing. Geographies and even zoning regulations, though very important to consider, do not change with the same frequency. It is important to keep in mind that the more adverse geographic conditions for new development are, the higher the impact that a boost in demand will have on house prices and rents. Low land availability will increasingly impact the cost of every additional developed unit due to engineering challenges and the need for demolition of pre-existing units. Slow zoning approvals will also do so in the short term, but the effect will mostly reverse once all delayed units are delivered. On the other hand, higher construction and operating costs will not increasingly impact the cost of every additional unit. They will directly affect all potential units on a similar scale (see *Figure 3*). Because of their price dependence on the business cycle, we can also say that construction and operating costs are more dynamic.

Figure 3. Stringent Zoning and Low Land Availability vs. Higher Construction Costs

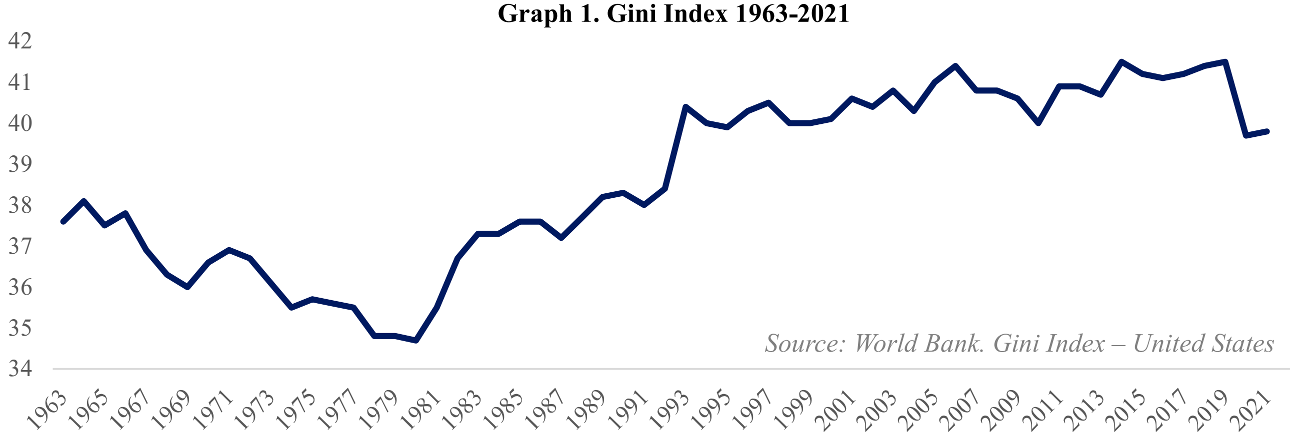


Price fluctuations for construction materials, equipment, and labor are just some of the many components of inflation. Price increases for these products and for residential operating costs, such as utilities, administration, and maintenance, can be caused by an increased appetite for their consumption, as could be the case with more business activity through expansionary monetary policy; or by increases to their production cost base, as could be the case with supply chain disruptions and labor shortage caused by a pandemic. The former would be referred to as *demand-pull inflation*, and the latter as *cost-push inflation*. Given that some products are largely dependent on others, inflation for some of these may spill over to others; meaning that increases in energy costs, for example, will spill over to other industries, such as steel and concrete production, construction machinery operation, and consequently, real estate development, forcing developers and landlords to charge higher rents to be profitable through *cost-push inflation*.

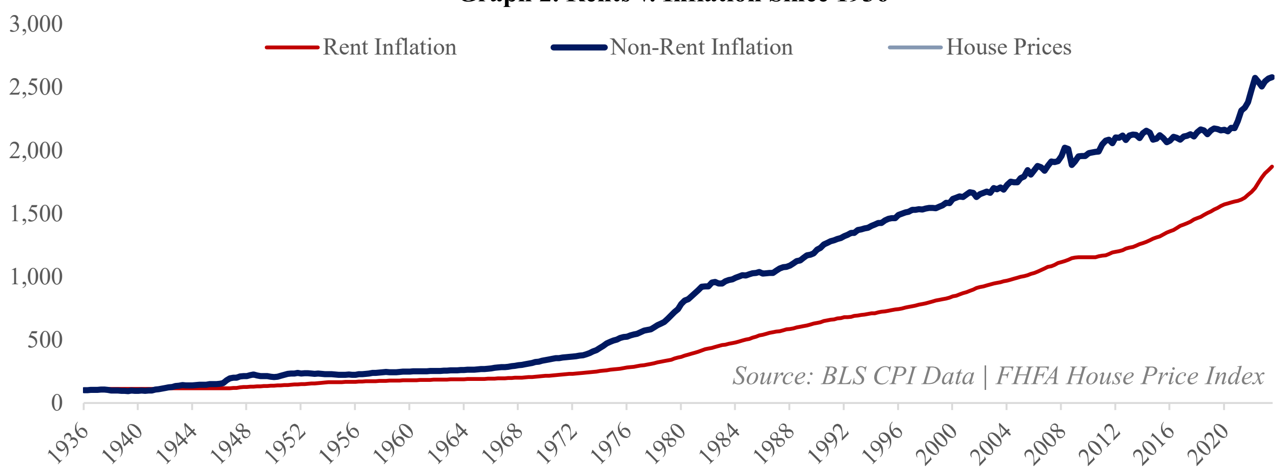
When inflation on housing rents — remember that owning and renting are similar from a financial standpoint — exceeds the one for other products, this means that costs for each additional housing unit increase more rapidly due to adversities in geographic, land, or zoning conditions; that inflation for construction and operating costs has been higher; or that demand for housing has increased unproportionately for some reason. A good way to visualize this is to compare rent inflation to the one in other components of the Consumer Price Index (CPI). Ideally, we would like to see rent inflation at or below non-rent inflation. According to the US Department of Housing and Urban Development (HUD), housing costs should make up around 30% of a household's income. Because they are not substitutable and because of their high impact on a typical household's budget, when these increase by more than other expenses, they can cause high financial pressure on households.

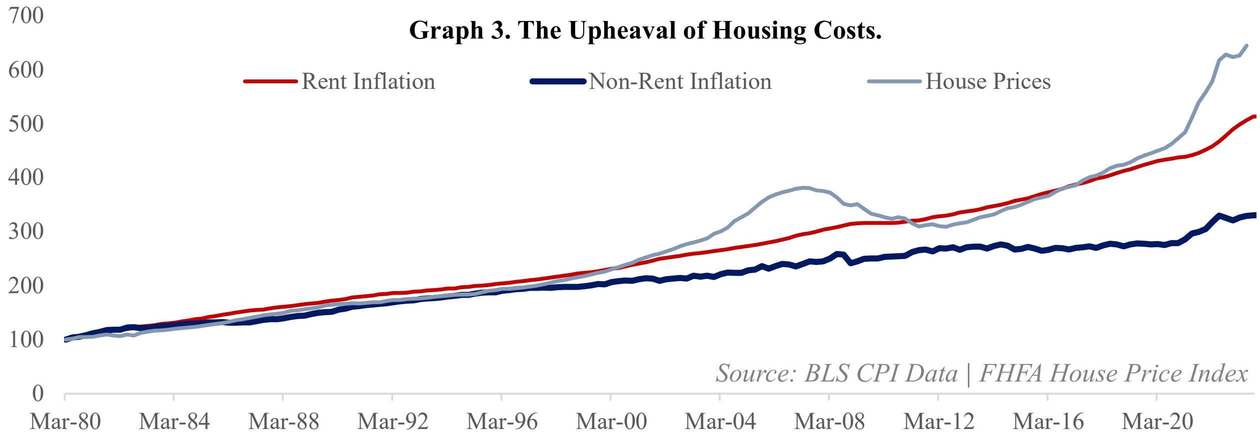
Analyzing these trends from 1936 — the year since we have complete quarterly data for rent inflation — onwards, we will see that inflation for rents has not caught on with the rest of the components of the CPI. This could be explained by the high inflationary periods of the 1940's and 1970's, which did not fully trespass into the real estate market due to price controls and the enactment of housing programs. However, if we analyze the data starting from the 1980's — when the 30% benchmark was defined — we will see that housing costs have increasingly outpaced non-rent inflation since the late 1990's. Factoring in the *Gini Index*, which measures income inequality and which has been rapidly rising since the early 1980's, we also know that income distribution in the country has been less equitable since then, increasing the difference in purchasing power of homeowners and renters. The current affordability crisis started to unfold with the coalescence of these two factors.

Graph 1. Gini Index 1963-2021



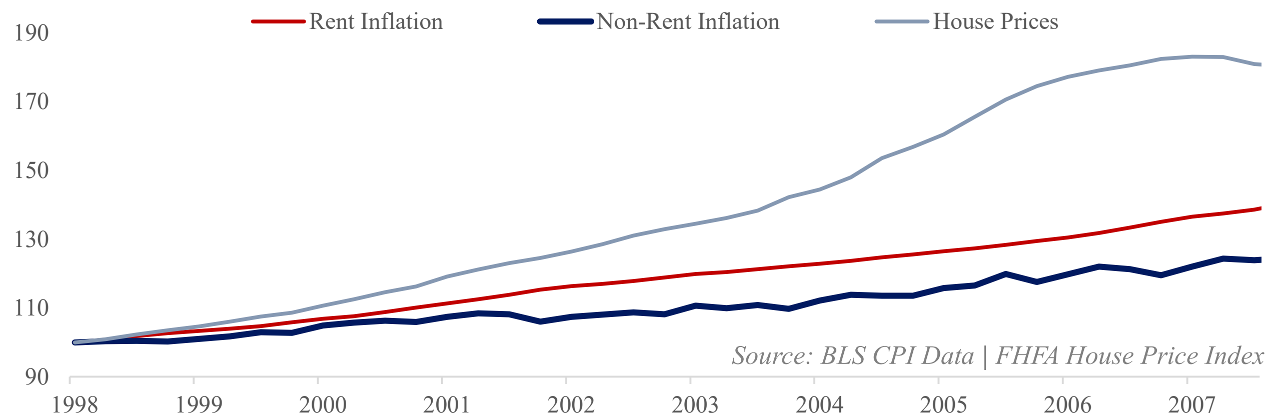
Graph 2. Rents v. Inflation Since 1936




700
600
500
400
300
200
100
0
Graph 3. The Upheaval of Housing Costs.
Rent Inflation
Non-Rent Inflation
House Prices
Source: BLS CPI Data | FHFA House Price Index
Mar-80
Mar-84
Mar-88
Mar-92
Mar-96
Mar-00
Mar-04
Mar-08
Mar-12
Mar-16
Mar-20

I. The American Dream

Graph 4. Road to the Global Financial Crisis.

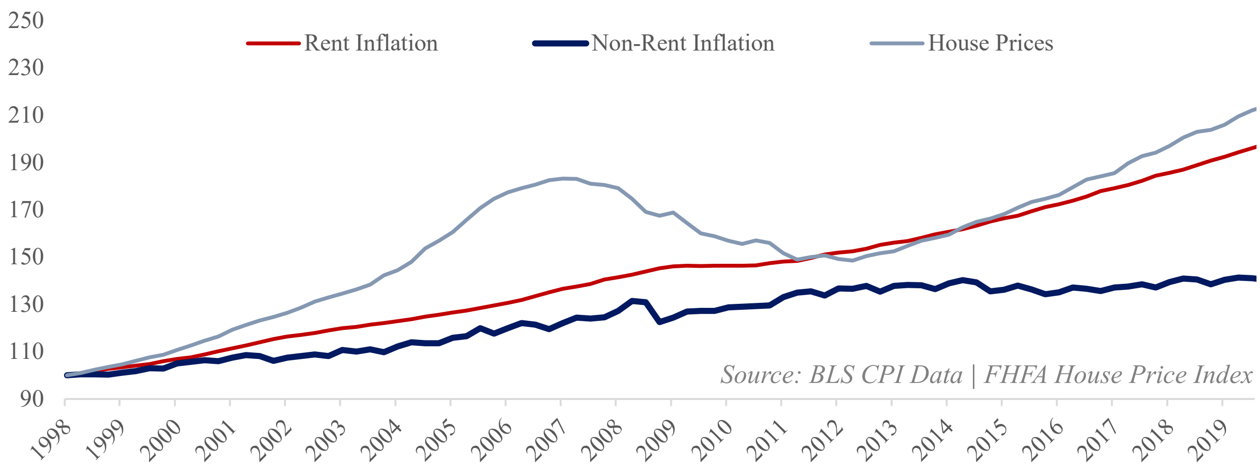


Homeownership has always been the dream for most, and in 1999, the Federal National Mortgage Association (Fannie Mae) began efforts to extend mortgage loans to those who had been left out by the financial system — to those with lower credit and savings than lenders typically required. Hence, came the subprime mortgages; loans to help households with higher credit risk and no savings for equity deposits afford a house. Loans that, of course, usually came with higher interest rates and variable payments at adjustable rates to compensate lenders for their higher risk.

Subprime loans were packed with other mortgages into large pools of loans and then sold as mortgage-backed securities (MBS) to create valuable investment products through financial engineering, and more tailored securities for third party investors. Large amounts of MBS were initially purchased and held by government sponsored enterprises, and eventually spread largely over the financial system. This led to irresponsible lenders and as one would expect, loans with low barriers for borrowers became very popular, very quickly, increasing housing demand and property values at a rapid pace. With prices booming and with low equity buffers in house values, MBS holders became highly exposed to the housing market, leaving them susceptible to a reversal in housing prices — which came around in 2007 when mortgage default rates started to rise. Given the exposure of the financial system to mortgage-backed securities, the economy collapsed in 2008 into what we know today as the Global Financial Crisis. With the housing market crashing, banks collapsing, and the stock market plummeting, the Federal Reserve faced a very complicated situation and had to come up with a solution.

II. The Global Financial Crisis

Graph 5. The Crash in the Global Financial

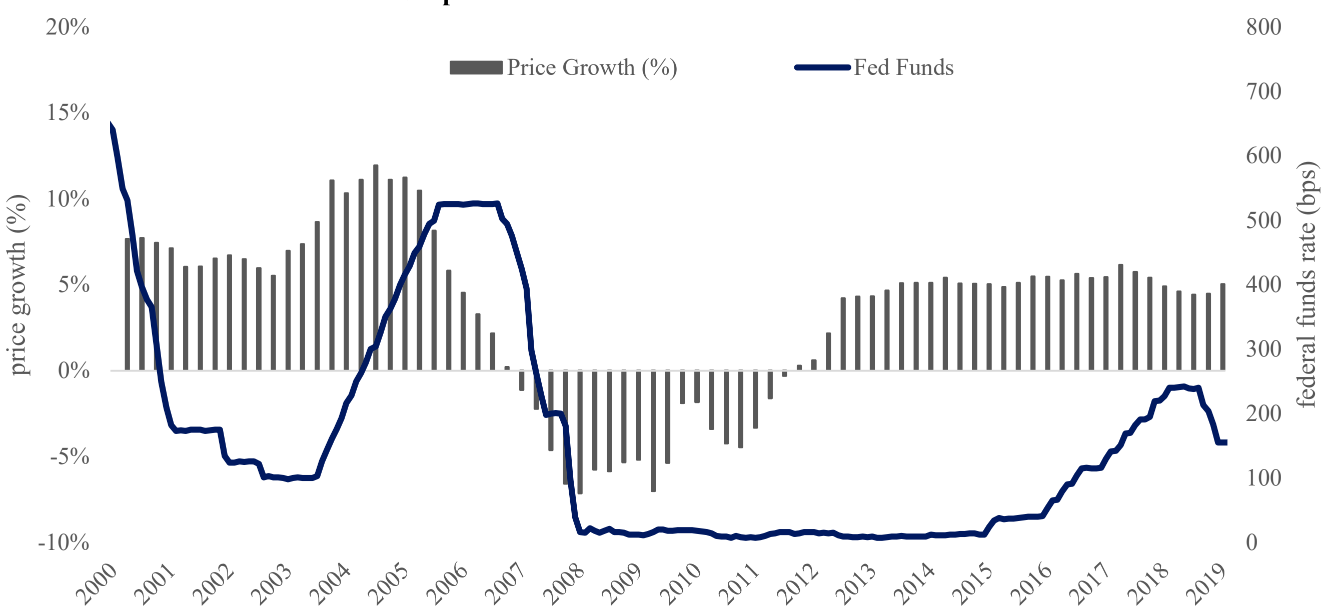


The housing bubble had nothing to do with the fundamentals of the space market. It was all driven by the financial system and irrational exuberance. However, the rise in house prices did lead to significant increases in residential rents, which did no more than stabilize during the recession. Surprising to see that these did not suffer much as the housing market collapsed, but not so surprising when we account for the massive shift of 5% of all households away from homeownership and into the rental market, increasing the renter's pool from 32% to 38% of all households. This shift gradually took place from the collapse in 2008 until 2016 and it was amplified by the low construction activity that trailed the Global Financial Crisis.

In the years that followed, rent inflation kept growing while average prices for the rest of the CPI remained practically stable — at least until 2020. This could probably be explained by the fed's reactive expansionary monetary policy and the implementation of Quantitative Easing (QE) to ease deflationary threats. These actions grew the monetary base (M0) — cash plus reserve deposits with central bank — without disrupting the growth for total money supply (M2) — M0 with money multiplier effect —, meaning that large sums of cash were kept by the by banks as reserves. This resulted in confident and healthy lenders, and not in a significant increase in cash in US households, keeping inflation for most consumer products at acceptable ranges and sparking economic growth. However, to implement this, part of the fed's strategy was to stabilize the housing market by purchasing $1.7 trillion of mortgage-backed securities (MBS), and to lower the federal funds rate to practically zero. This reactivated mortgage lending at low interest rates and increased demand and prices for housing, again. Although, after lessons learned from the Global Financial Crisis, lending was extended to buyers with a higher credit rating and with higher equity requirements, increasing bifurcation of the housing market by attracting the wealthier into ownership and by pushing lower income earners into the rental market — further increasing house prices.

Additionally, with house construction lagging due to the aftermath of the recession, demand for new housing outpaced developers and led to further increases in home prices and rents. Households who could not afford down payments for increasingly expensive houses were forced into a costly rental market without an alternative other than to spend large portions of their income in rent, exacerbating housing affordability problems. Although, after almost 8 years of near-zero interest rates and 3 rounds of QE that financially stimulated house prices and therefore rents, the Fed decided to reverse their expansionary cycle. Interest rates started rising in 2015 and by 2019 the federal funds rate had risen above 240 bps. At more reasonable financing costs, it was only a matter of time until house price growth started to cool down — at least in part —, lowering rent growth and stabilizing the economy at an overall inflation rate near the Fed's 2.0% target. Sounded like a victory after the Great Recession. However, no one expected that we were less than a year away from facing the most severe pandemic in over 100 years.

Graph 6. Interest Rates vs. Home Price Growth



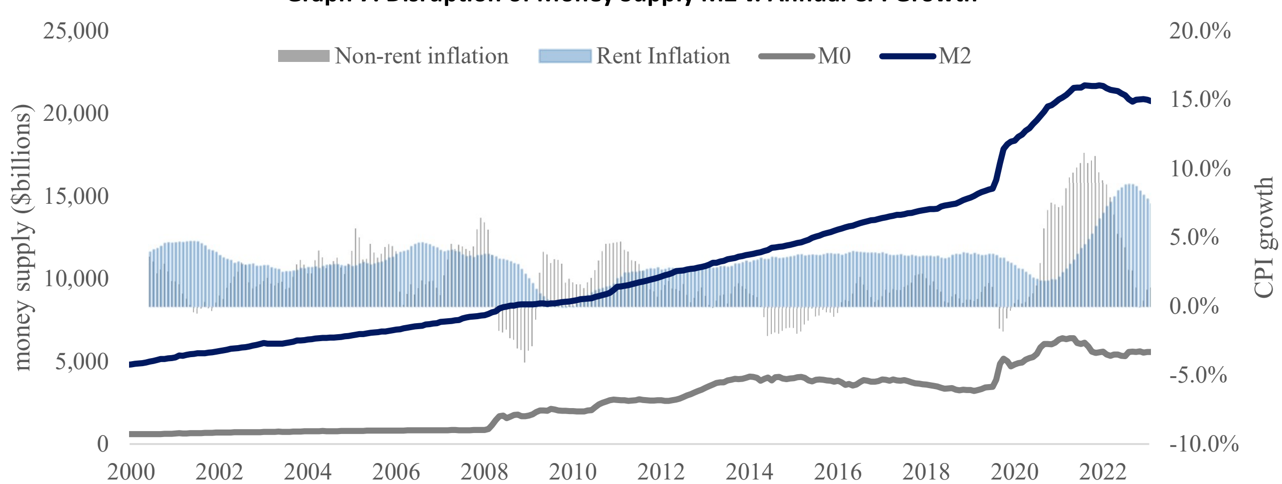
Source: Federal Reserve of St. Louis. Federal Funds Effective Rate | FHFA. House Price Index

III. The Pandemic

Since the World Health Organization officially declared COVID-19 a global pandemic in March 2020, house pricing and rent growth have accelerated even more, and now they are not growing alone. Additional rounds of QE, coupled with stimulus checks, significantly increased the total money supply (M2) in the US, driving up prices for most consumer products. This, coupled with changes brought by the pandemic, resulted in a boom in housing costs — again. After realizing that work from home was not going anywhere, households were naturally inclined to place more value on where they live — and work for that matter. Just the perfect timing for the government to flood the economy with $814 billion in stimulus checks. This was ultimately coupled with disruptions in labor markets and supply chains due to the pandemic, driving inflation for construction costs. Apart from all of this, it's not hard to imagine how the Fed aided their QE program this time — that's right, by purchasing almost $700 billion in MBS, bringing mortgage rates to a new low of 2.7%.

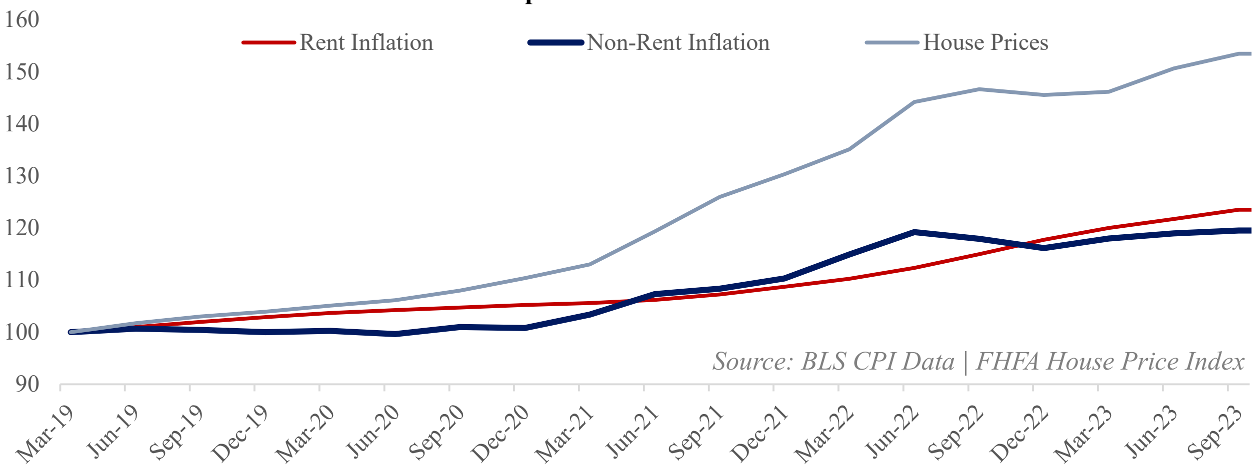
Picture a market where households are willing to spend more in housing and most renters are getting free checks from the government; mortgage rates are being forced to be lower than they should be based on their intrinsic risk; and developers lack labor and materials to build new homes and catch up with a drastic increase in demand. Just when the Fed was starting to reverse their expansionary cycle, they had to quickly respond to what seemed to be a great threat for deflation. They did so by almost doubling the amount of cash (M0) in the US economy, the government spread more than half of this cash to households through fiscal stimulus, and housing costs, of course, soared to a new and unaffordable high.

Graph 7. Disruption of Money Supply M2 v. Annual CPI Growth



Source: Federal Reserve of St. Louis. M2 & M0 Supply | BLS. CPI Data

Graph 8. The Pandemic.



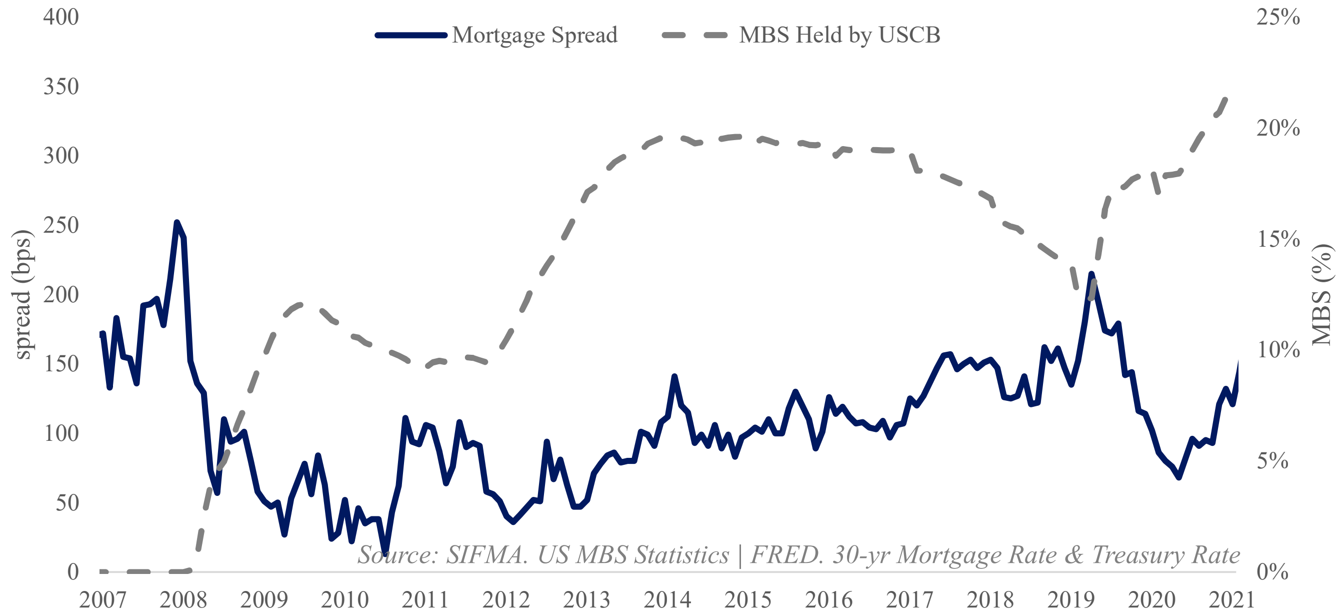
IV. The Housing Crisis

Given that the goal for many households is to own their home, whenever they reach financial stability and the net-worth requirement to make the investment, they jump from the renter's pool into the homeowner's pool. The median household income for homeowners is around 1.4 times higher than the one of renters; and 34% of renters are 35 years old or younger, compared to 10% of homeowners. For the most part, it is the younger and the lower income earners that rent, but their housing costs are being highly affected by the increases in home prices because financially stable households can freely choose between the two options, driving rents up too. Because the homeowner's pool is considerably larger, periods with a higher household flow into the rental market heavily impact demand for rental units, allowing landlords to charge higher rents. However, when the cycle is reversed and apartment supply exceeds its demand, it is vacancies that suffer, but rental rates do not usually decrease, leaving lower income earners in a difficult situation. Higher demand for housing, increasing income inequality, and an inadequate mix of rental products in the market have burdened almost 50% of renters with unaffordable housing costs.

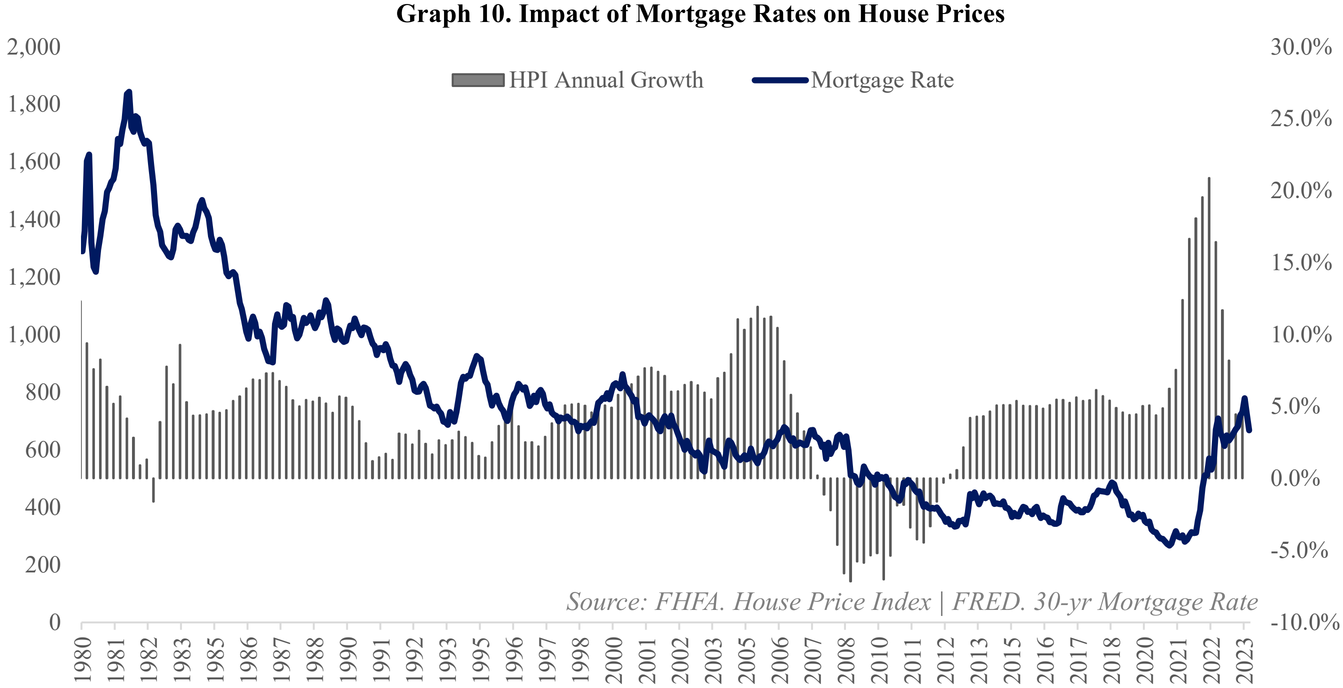
Focusing on demand and specifically on monetary policy, the manipulation of mortgage-backed security yields and reliance on these instruments to improve access to homeownership since the late 90's, along with near-zero interest rates for prolonged periods of time have further inflated residential values— affecting lower income earners by burdening them with higher rents, and inflating home equity for those who were able to afford a house in the beginning. Today, around 14% of outstanding residential loans are backed by MBS purchased by the Central Bank, representing 20% of the United States MBS market — all of which have lowered mortgage rates during periods of QE, forcing issuers around those times to also underwrite these securities at low yields due to the reduction in available MBS supply. This has allowed for mortgage loans to be continuously extended at artificially low rates, inflating home values.

After four rounds of mortgage-rate stimulation, around ten years of near-zero federal funds rates, and unnecessary home price increases, what happens when the Fed hits the breaks, raises rates, and the cost for the average 30-year mortgage increases from 2.9% to 7.1% in just 14 months? Fortunately, this time, only around 20% outstanding mortgage loans are on adjustable rates and most mortgage loans have a healthy equity buffer. But, with a much tighter monetary policy and inflation slowdown for most CPI components, will house prices and rents finally cool down? And if so, how long will it take for this to happen? Important to remember that rents are highly dependent on house prices and inflation. With growth for both variables finally coming to a halt, how long can we expect for rent growth to cool down? These are the dynamics that we will explore in this paper, and we will take a closer look at them in the next section.

Graph 9. Impact of QE on Mortgage Rate Spread | 30-yr mortgage to 30-yr treasury



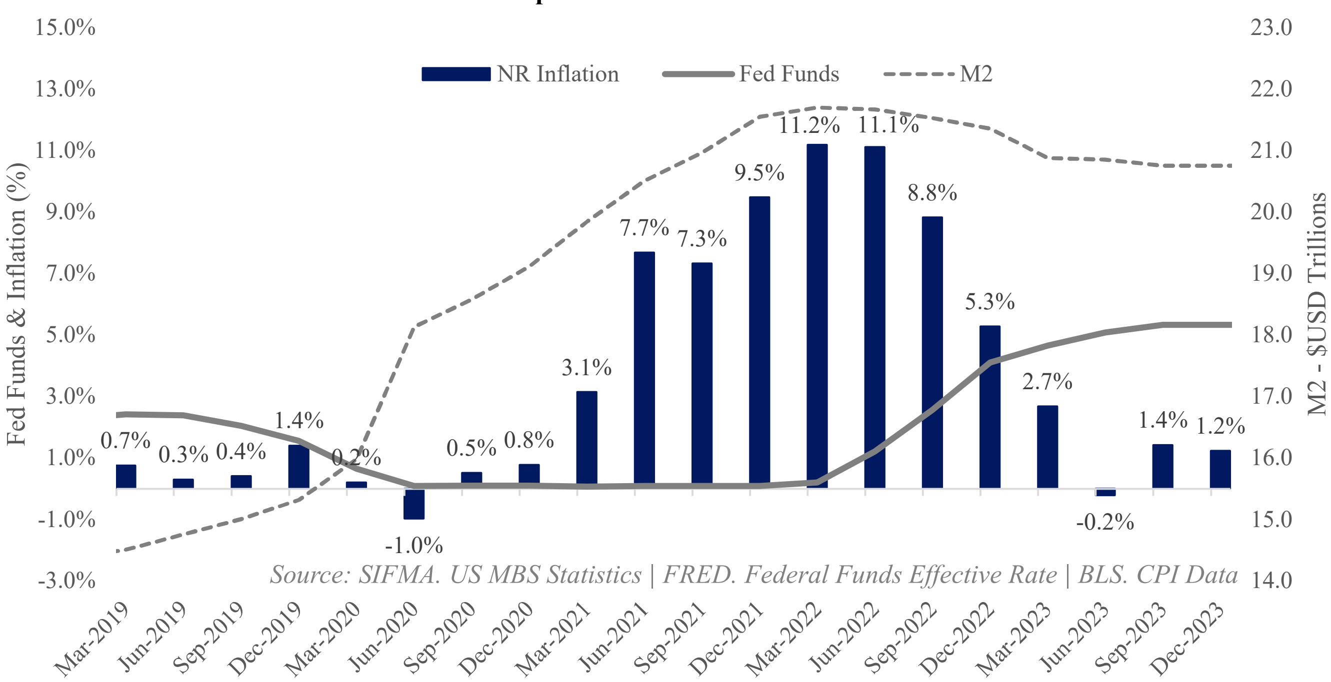
Graph 10. Impact of Mortgage Rates on House Prices



RENTS, HOUSE PRICES, AND INFLATION

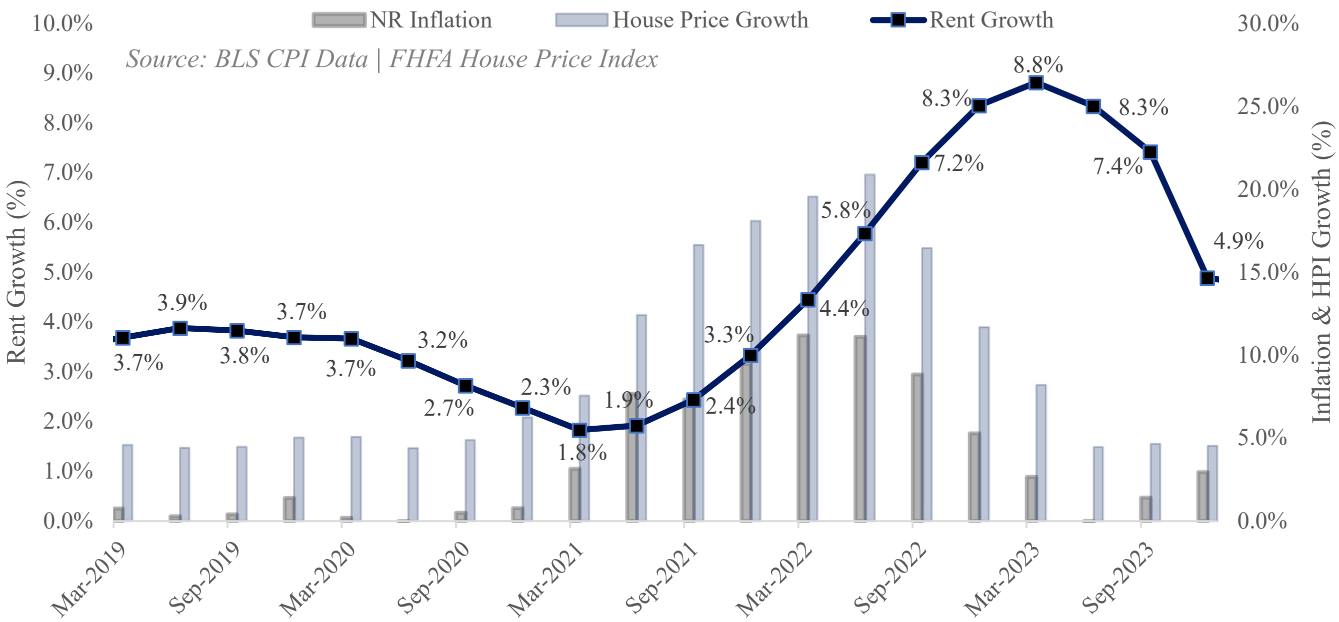
With the recent change in monetary policy, the federal funds rate hiked from practically zero to over 530 bps in 18 months; the money supply M2 decreased by over $700 billion over the same period; and mortgage rates more than doubled from a low of 270 bps. Inflation for non-rent products is finally slowing down and house prices are growing at much lower rates. We know that this should impact rent growth, which is already cooling down, but it was still well above the annual 1.2% inflation for non-rent products in 2023 Q4. If the Consumer Price Index is still considerably higher, it is because rents were growing at an annual rate of 4.9% over the same period. A slowdown in rent growth would bring inflation back under control, but to try to understand these trends, we must consider that changes in house prices and inflation do not necessarily impact rents immediately. To model the rate and the lag at which changes in inflation and house prices trespass into rents, we must run an *Error Correction Model (ECM)*, which will be further explained soon.

Graph 11. Post-COVID Non-Rent Inflation



Source: SIFMA. US MBS Statistics | FRED. Federal Funds Effective Rate | BLS. CPI Data

Graph 12. Post-COVID Rent Growth



Our analysis will compare the relationship between rents, house prices, and inflation at a national level and at individual Metropolitan Statistical Areas (MSA). We will do so with MSAs that have enough quarterly data for rent inflation and local Housing Price Index (HPI). By analyzing different areas, we will appreciate how different geographical and market characteristics impact the trespassing of inflation and house prices into rents; we will see how these two variables will impact overall inflation in different cities and circumstances and how those compare to the national average. We will go through this analysis by running another ECM for the United States, Boston, Chicago, Dallas, Detroit, Houston, Los Angeles, Miami, New York, Philadelphia, and San Francisco.

Now, before we get into these analyses, let's talk about *Error Correction Models.* An ECM is a statistical technique used to analyze the relationship between variables when they exhibit both short-term dynamics and long-term equilibrium. This model is particularly useful to examine economic trends, in which typically, deviations from equilibrium between variables are adjusted in the long run, despite short-term fluctuations. We will use this model because of its ability to correct for discrepancies from the long-term equilibrium relationship between variables. By accommodating lags and adjustments, the ECM will enhance the precision and reliability of our analysis and examine the interdependencies and temporal relationships within our economic framework.

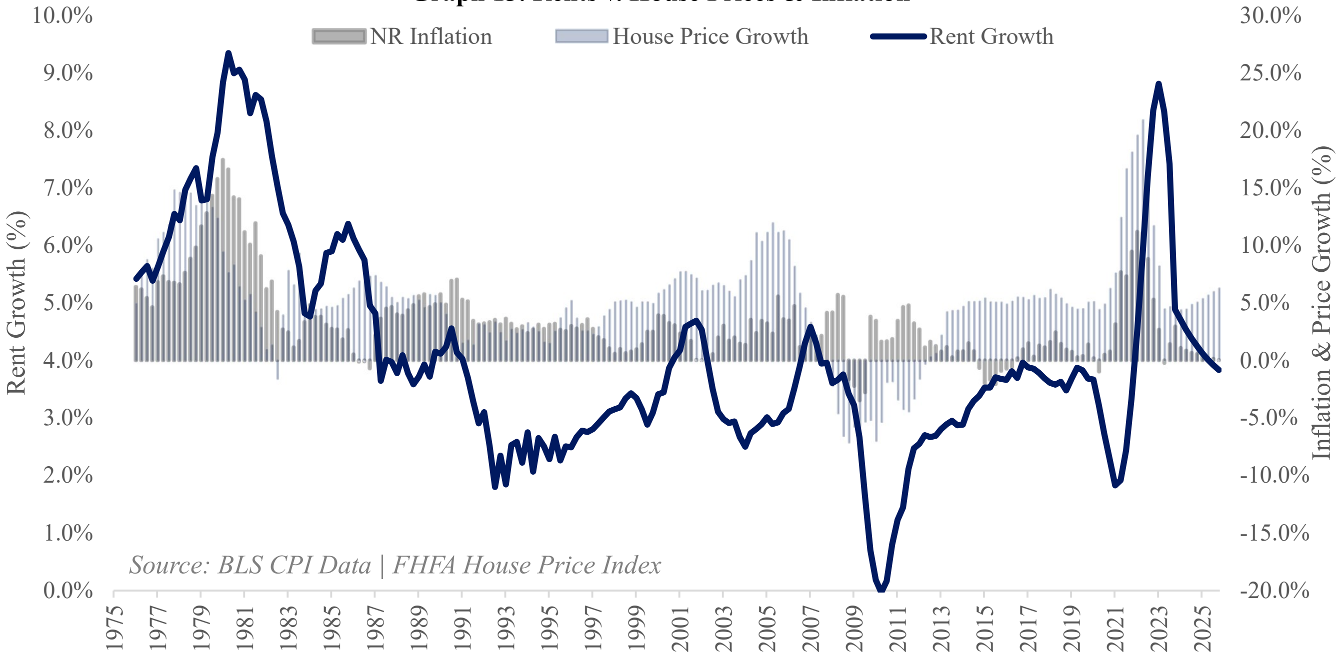
In this paper, the application of an *Error Correction Model* is crucial due to the inherent lag from changes in house prices and inflation into changes in rents. Specifically, this model will be used for understanding (i) the relationship between inflation, house prices, and rents in the United States; and (ii) for the analysis of these variables in ten Metropolitan Statistical Areas. Our ECMs will be represented by the following equation:

$$\Delta I = C + \underbrace{a(\Delta A) + b(\Delta B) + [\ldots] + n(\Delta N)}_{\text{Short Term}} + \underbrace{i(\Delta I_{t-1})}_{\text{Long Term}}$$

Where *C* represents a constant; ΔI represents the change in our dependent variable; ΔA, ΔB, and ΔN represent the change in our independent variables; *a, b* and *n* represent the change in ΔI for every unit change in each independent variable in a single period; and *i* represents the change in ΔI for every unit change in *I* in the previous period. The interpretation of these variables might be hard to grasp, but it is easier to understand that (1-*i*) is the periodic rate at which short-term changes affect our dependent variable in the long term. As an example, if *i* = 0.80, (1-*i*) would be equal to 0.20, meaning that the short-term changes represented in the first part of the equation, only represent 20% of their long-term impact; so, if $a(\Delta A) = 10$, the short-term impact changes to *I* resulting from the change in variable *A* will be equal to 10 units, and it would represent 20% of its long-term impact, which will be $\frac{10}{0.2} = 50$ units. The periodic rate at which this long-term change will take place is 20%, meaning that the long-term impact will be reflected in full after $\frac{1.0}{0.2} = 5$ periods.

I. House Prices and Inflation on Rents

Graph 13. Rents v. House Prices & Inflation



$$R^2 = 0.97$$

$$\Delta RCPI = 0.00 + 0.04(\Delta NCPI) + 0.03(\Delta HPI) + 0.92(\Delta RCPI_{t-1})$$

Our first model uses an *ECM* to describe the relationship between *annual percentage inflation for rents (ΔRCPI),* the *annual percentage inflation for non-rent products (ΔNCPI),* and the *annual percentage growth in house prices (ΔHPI)*. This *Error Correction Model* explains 97% of the variations in rent inflation and has a very strong statistical reliability. The complete output for this analysis can be found in *Appendix A*, and its short-term and long-term dynamics in this model are summarized in the following table:

Table 1. Short and Long-Term Dynamics of Rent Inflation

Variable	Coefficient	Variation (e.g.)	Short-Term	Long-Term	Total Lag
Intercept	0.00	NA	+0.05%	+0.6%	13 Qs
%NCPI Growth	0.04	+1.0%	+0.04%	+0.5%	13 Qs
%HPI Growth	0.03	+1.0%	+0.03%	+0.4%	13 Qs
%RCPI Growth (-1)	0.92	NA	NA	NA	NA

As an example, the third column (Variation) in the previous table defines a hypothetical shift in each variable. The columns that follow indicate the short-term and long-term impacts of that variation on ΔRCPI, as well as the total lag for the long-term impact to fully develop. So, if inflation for non-rent products or annual house prices increased by 1.0%, inflation for rents would increase by 0.04% and 0.03%. If both independent variables increased by 1.0% simultaneously, our dependent variable would grow by 0.07%. These increases represent the short-term impact of this model, which would happen over a single quarter. However, after 13 quarters, the total impact of that 1.0% increase in house prices and non-rent inflation, would be of 0.5% and 0.4% respectively — around 12.5 times larger. This model not only explains most of the variance in rent inflation (97%), but it also trespasses most of the percentual changes in inflation and house prices into rents. For example, a 1.0% change in house prices and in non-rent inflation (see *Table 1*) would change rents by 0.9%, meaning that 90% of the increases to these two variables affect rent inflation in the United States. Also, interesting to see that an increase in house prices — a case of *demand-pull inflation* — would have almost the same impact as an increase in costs for other products — a case of *cost-push inflation* — with the second variable having a slightly higher influence (0.5% v. 0.4%). However, this does not mean that cost-push inflation has been to blame for the increase in rents, on the contrary, the largest contributor has been the increase in house prices. This is true because the growth for house prices has far exceeded inflation since the start of our analysis.

II. Rent Inflation by Area

Table 2 has the summary results to our rent *Error Correction Models* for the United States and for 10 *Metropolitan Statistical Areas* for which we have full quarterly data since 1978 Q2 — the date was set to allow for the inclusion of the full rent series for Miami, which starts then. This table shows the coefficients and the lags for every variable in each model. The lag indicates the number of past quarters that the independent variable comes from. For example, New York's model predicts rent growth based on the quarterly change in NCPI and HPI from two previous periods, while the model for Miami uses the quarterly growth in those variables in the same period. Error Correction Models with various period lags were run for every MSA, and the ones with the highest correlation and the highest trespass rates of inflation and house price growth into rents were chosen. *Appendix B* shows the summary results for all these regressions and the model selection for every area.

Table 2. Results for Rent Inflation Models in the United States

ID	Model	Constant	ΔNCPI	ΔHPI	ΔRCPI (-1)	Lag NCPI	Lag HPI	R^2
0	USA	0.0004	0.0435	0.0296	0.9176	0	0	0.9677
1	Boston	0.0045	0.1493	0.0662	0.6781	4	4	0.8452
2	Chicago	0.0050	0.0869	0.0246	0.7758	1	1	0.7979
3	Dallas	0.0019	0.0711	0.0926	0.7775	0	0	0.8526
4	Detroit	0.0039	0.0551	0.0328	0.7891	0	0	0.8108
5	Houston	0.0013	0.1390	0.0749	0.7296	2	2	0.7513
6	Los Angeles	0.0013	0.0585	0.0154	0.9033	0	0	0.9263
7	Miami	0.0002	0.1149	0.0636	0.8242	0	0	0.8612
8	New York	0.0037	0.0622	0.0275	0.8148	2	2	0.8751
9	Philadelphia	0.0017	0.0774	0.0276	0.8509	1	1	0.8795
10	San Francisco	0.0018	0.0805	0.0242	0.8674	2	2	0.8617

Table 3 shows the analysis of these coefficients to allow a better interpretation of the models. The first column, *Trespass*, shows the percentage impact on rent inflation for every unit change in *non-rent inflation* (*NPCI*) and *house price growth* (*HPI)*. So, an increase of 100% in house prices and non-rent inflation would translate into an 89% increase in rents in the United States, but only to a 50% increase in Chicago. Then comes the *Lag*, which is the number of quarterly periods that it takes for changes in the

independent variables to bring rents into a long-run equilibrium. To the right, we will see the accumulated growth in our independent variables from 1978 Q2 until 2023 Q3. *Non-Rent Inflation (NCPI)* is a national variable; it is the annual inflation for non-rent products in the *Consumer Price Index*, and the series is repeated for the model of every city. However, *House Price Growth (HPI)* is a local variable, as it follows the annual growth in the *House Price Index* for every MSA. Finally, we have the impacts that our independent variables have had in rent inflation since the start of the analysis (*LT NCPI and LT HPI)* — the impact of the constants was not included because it is almost negligible, as can be seen in *Table 2*. These last two are the most important columns of this table, and maybe the most relevant finding in this paper, as they indicate the proportion of *demand-pull* (HPI) and *cost-push inflation* (NCPI) in each of these locations. As we can see, in the United States, as in most of these Cities, *demand-pull inflation* has been the main driver for increases in rents.

Table 3. Analysis of Rent Inflation Models in the United States

ID	Model	Trespass	Lag (Q)	∆NCPI	∆HPI	∆RCPI	LT NCPI	LT HPI
0	United States	89%	13	319%	694%	485%	1.69x	2.50x
1	Boston	67%	4	319%	1587%	549%	1.48x	3.26x
2	Chicago	50%	5	319%	449%	466%	1.24x	0.49x
3	Dallas	74%	5	319%	641%	464%	1.02x	2.67x
4	Detroit	42%	5	319%	490%	350%	0.83x	0.76x
5	Houston	79%	4	319%	420%	341%	1.64x	1.16x
6	Los Angeles	76%	11	319%	1282%	623%	1.93x	2.05x
7	Miami	102%	6	319%	1259%	572%	2.09x	4.56x
8	New York	48%	6	319%	1254%	514%	1.07x	1.86x
9	Philadelphia	70%	7	319%	859%	428%	1.66x	1.59x
10	San Francisco	79%	8	319%	1511%	702%	1.94x	2.75x

Apart from the possible permanent change in geographic conditions and zoning policies in these areas — as would be the case due to wetland designations, the implementation of environmental regulations, or change in flooding patterns that would force mitigation expenses — inflation for non-rent products would account for all cost-push inflation in housing due to spillovers from related industries. Demand-pull inflation on the other hand can be interpreted as the force by which house price growth pulls on rents, due to the shift in household preferences to rent until prices for owning and renting fall to an equilibrium. If cost-push inflation were the only driver for increases in rents, the HPI variable in these models would not show any statistical strength or its long-term impact on rents (*LT HPI)* would be closer to zero. This would mean that inflation for non-rent products spills over to residential construction and operation for renters and homeowners alike, and that variations in house prices do not trespass into rents. However, this is not the case, and for the US average and for most cities — except for Houston, Detroit, and Chicago — the effect of demand-pull inflation caused by increasing house prices has dominated. *Appendix C* shows the full outputs and statistical strengths for all these regressions.

Variation in trespassing rates could be explained by various factors. One logical explanation is that if increases in our independent variables do not fully trespass into rent growth, the homeownership and rental markets in that city are bifurcated when compared to the rest of the country: probably due to product differentiation, suburban vs urban locations, or simply different preferences between socioeconomic groups. Inflation for non-rent products could also not be fully trespassing into residential construction and operation due to irregularities in some cost components such as wages or energy prices. Variation in the impacts of demand-pull and cost-push inflation though, seem to be highly correlated with the supply elasticity — or the difficulty with which developers can build new residential units — in each market. Cities in which demand-push inflation has been lower are the ones in which geographic and regulatory conditions make it easier to develop new units, and these cities are clearly the minority in the United States, as we can see in the analysis of the model for the country's average.

Complementing these tables, *Appendix D* contains graphs to compare growth in our three variables since the start of the analysis, and the periodic annual growth in non-rent products and house prices versus the accumulated increase in rents. There are two graphs for each MSA, and their purpose is to showcase the scale at which rents, and house prices have outpaced inflation for non-rent products since the start of our analysis; and to visually support the impact of annual house price increases and inflation on annual rent growth. These are very similar to the graphs that were previously shown for the United States, and their relevant quantitative information is already shown in the previous tables. However, it is still worth it to take a look at them and appreciate the different behavioral patterns of our variables in each city.

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APPENDIX A: HOUSE PRICES AND INFLATION ON RENTS

Regression Statistics	
Multiple R	0.984113481
R Square	0.968479343
Adjusted R Squ	0.967973664
Standard Error	0.00340228
Observations	191

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	3	0.06650844	0.02216948	1915.205821	4.481E-140
Residual	187	0.00216462	1.15755E-05		
Total	190	0.06867306			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	0.000469379	0.000598243	0.784594807	0.43368397	-0.000710794	0.001649551	-0.000710794	0.001649551
USDNCPI	0.041719674	0.008346279	4.998595774	1.32266E-06	0.025254711	0.058184637	0.025254711	0.058184637
DHPI	0.028714051	0.005817133	4.93611766	1.75783E-06	0.017238413	0.040189689	0.017238413	0.040189689
DRCPI{1}	0.919768341	0.015352086	59.91161997	5.4541E-124	0.889482805	0.950053878	0.889482805	0.950053878

APPENDIX B: RENT INFLATION BY AREA – MODEL SELECTION

Table 4. Error Correction Model Selection

ID	Region	Var 1	Value	Var 2	Value	Var 3	Value	Var 4	Value
0	United States	Constant	0.0004	Constant	0.0023	Constant	0.0018	Constant	0.0010
0	United States	USDNCPI	0.0435	USDNCPI {4}	0.0376	USDNCPI {2}	0.0616	USDNCPI {1}	0.0536
0	United States	DHPI	0.0296	DHPI{4}	0.0451	DHPI{2}	0.0415	DHPI{1}	0.0365
0	United States	DRCPI{1}	0.9176	DRCPI{1}	0.8541	DRCPI{1}	0.8523	DRCPI{1}	0.8861
0	United States	Trespass	89%	Trespass	57%	Trespass	70%	Trespass	79%
0	United States	In x Years	3.04	In x Years	1.71	In x Years	1.69	In x Years	2.20
0	United States	R2	0.9677		0.9637		0.9723		0.9715
1	Boston	Constant	0.0033	Constant	0.0045	Constant	0.0034	Constant	0.0032
1	Boston	USDNCPI	0.0600	USDNCPI {4}	0.1493	USDNCPI {2}	0.0973	USDNCPI {1}	0.0845
1	Boston	DHPI	0.0342	DHPI{4}	0.0662	DHPI{2}	0.0610	DHPI{1}	0.0410
1	Boston	DRCPI{1}	0.8255	DRCPI{1}	0.6781	DRCPI{1}	0.7496	DRCPI{1}	0.7999
1	Boston	Trespass	54%	Trespass	67%	Trespass	63%	Trespass	63%
1	Boston	In x Years	1.43	In x Years	0.78	In x Years	1.00	In x Years	1.25
1	Boston	R2	0.8179		0.8452		0.8361		0.7496
2	Chicago	Constant	0.0046	Constant	0.0067	Constant	0.0056	Constant	0.0050

2	Chicago	USDNCPI	0.0710	USDNCPI {4}	0.0954	USDNCPI {2}	0.0925	USDNCPI {1}	0.0869
2	Chicago	DHPI	0.0151	DHPI{4}	0.0448	DHPI{2}	0.0322	DHPI{1}	0.0246
2	Chicago	DRCPI{1}	0.8104	DRCPI{1}	0.6986	DRCPI{1}	0.7450	DRCPI{1}	0.7758
2	Chicago	Trespass	45%	Trespass	47%	Trespass	49%	Trespass	50%
2	Chicago	In x Years	1.32	In x Years	0.83	In x Years	0.98	In x Years	1.11
2	Chicago	R2	0.7886		0.8038		0.8009		0.7979
3	Dallas	Constant	0.0019	Constant	0.0028	Constant	0.0023	Constant	0.0021
3	Dallas	USDNCPI	0.0711	USDNCPI {4}	0.0826	USDNCPI {2}	0.1039	USDNCPI {1}	0.0925
3	Dallas	DHPI	0.0926	DHPI{4}	0.0387	DHPI{2}	0.0913	DHPI{1}	0.0792
3	Dallas	DRCPI{1}	0.7775	DRCPI{1}	0.8070	DRCPI{1}	0.7365	DRCPI{1}	0.7684
3	Dallas	Trespass	74%	Trespass	63%	Trespass	74%	Trespass	74%
3	Dallas	In x Years	1.12	In x Years	1.30	In x Years	0.95	In x Years	1.08
3	Dallas	R2	0.8526		0.8349		0.8511		0.8482
4	Detroit	Constant	0.0039	Constant	0.0042	Constant	0.0042	Constant	0.0041
4	Detroit	USDNCPI	0.0551	USDNCPI {4}	0.0089	USDNCPI {2}	0.0392	USDNCPI {1}	0.0436
4	Detroit	DHPI	0.0328	DHPI{4}	0.0272	DHPI{2}	0.0355	DHPI{1}	0.0333
4	Detroit	DRCPI{1}	0.7891	DRCPI{1}	0.8325	DRCPI{1}	0.7921	DRCPI{1}	0.7940

4	Detroit	Trespass	42%	Trespass	22%	Trespass	36%	Trespass	37%
4	Detroit	In x Years	1.19	In x Years	1.49	In x Years	1.20	In x Years	1.21
4	Detroit	R2	0.8108		0.8033		0.8089		0.8087
5	Houston	Constant	0.0021	Constant	0.0025	Constant	0.0013	Constant	0.0019
5	Houston	USDNCPI	0.0370	USDNCPI {4}	0.1372	USDNCPI {2}	0.1390	USDNCPI {1}	0.0879
5	Houston	DHPI	0.1353	DHPI{4}	0.0376	DHPI{2}	0.0749	DHPI{1}	0.0916
5	Houston	DRCPI{1}	0.7424	DRCPI{1}	0.7408	DRCPI{1}	0.7296	DRCPI{1}	0.7446
5	Houston	Trespass	67%	Trespass	67%	Trespass	79%	Trespass	70%
5	Houston	In x Years	0.97	In x Years	0.96	In x Years	0.92	In x Years	0.98
6	Los Angeles	Constant	0.0013	Constant	0.0026	Constant	0.0019	Constant	0.0015
6	Los Angeles	USDNCPI	0.0585	USDNCPI {4}	0.0171	USDNCPI {2}	0.0587	USDNCPI {1}	0.0574
6	Los Angeles	DHPI	0.0154	DHPI{4}	0.0266	DHPI{2}	0.0257	DHPI{1}	0.0258
6	Los Angeles	DRCPI{1}	0.9033	DRCPI{1}	0.8877	DRCPI{1}	0.8736	DRCPI{1}	0.8836
6	Los Angeles	Trespass	76%	Trespass	39%	Trespass	67%	Trespass	71%
6	Los Angeles	In x Years	2.59	In x Years	2.23	In x Years	1.98	In x Years	2.15
6	Los Angeles	R2	0.9263		0.9253		0.9291		0.9302
7	Miami	Constant	0.0002	Constant	0.0037	Constant	0.0020	Constant	0.0011

7	Miami	USDNCPI	0.1149	USDNCPI {4}	0.1567	USDNCPI {2}	0.1892	USDNCPI {1}	0.1505
7	Miami	DHPI	0.0636	DHPI{4}	0.0755	DHPI{2}	0.0836	DHPI{1}	0.0646
7	Miami	DRCPI{1}	0.8242	DRCPI{1}	0.6880	DRCPI{1}	0.6891	DRCPI{1}	0.7706
7	Miami	Trespass	102%	Trespass	74%	Trespass	88%	Trespass	94%
7	Miami	In x Years	1.42	In x Years	0.80	In x Years	0.80	In x Years	1.09
7	Miami	R2	0.8612		0.8447		0.8706		0.8609
8	New York	Constant	0.0029	Constant	0.0055	Constant	0.0037	Constant	0.0032
8	New York	USDNCPI	0.0305	USDNCPI {4}	0.0592	USDNCPI {2}	0.0622	USDNCPI {1}	0.0475
8	New York	DHPI	0.0191	DHPI{4}	0.0392	DHPI{2}	0.0275	DHPI{1}	0.0253
8	New York	DRCPI{1}	0.8743	DRCPI{1}	0.7573	DRCPI{1}	0.8148	DRCPI{1}	0.8451
8	New York	Trespass	39%	Trespass	41%	Trespass	48%	Trespass	47%
8	New York	In x Years	1.99	In x Years	1.03	In x Years	1.35	In x Years	1.61
8	New York	R2	0.8616		0.8746		0.8751		0.8705
9	Philadelphia	Constant	0.0015	Constant	0.0027	Constant	0.0021	Constant	0.0017
9	Philadelphia	USDNCPI	0.0662	USDNCPI {4}	0.0827	USDNCPI {2}	0.0921	USDNCPI {1}	0.0774
9	Philadelphia	DHPI	0.0211	DHPI{4}	0.0378	DHPI{2}	0.0294	DHPI{1}	0.0276
9	Philadelphia	DRCPI{1}	0.8751	DRCPI{1}	0.8044	DRCPI{1}	0.8247	DRCPI{1}	0.8509

9	Philadelphia	Trespass	70%	Trespass	62%	Trespass	69%	Trespass	70%
9	Philadelphia	In x Years	2.00	In x Years	1.28	In x Years	1.43	In x Years	1.68
9	Philadelphia	R2	0.8759		0.8776		0.8823		0.8795
10	San Francisco	Constant	0.0015	Constant	0.0028	Constant	0.0018	Constant	0.0016
10	San Francisco	USDNCPI	0.0583	USDNCPI {4}	0.0667	USDNCPI {2}	0.0805	USDNCPI {1}	0.0642
10	San Francisco	DHPI	0.0251	DHPI{4}	0.0092	DHPI{2}	0.0242	DHPI{1}	0.0304
10	San Francisco	DRCPI{1}	0.8911	DRCPI{1}	0.8773	DRCPI{1}	0.8674	DRCPI{1}	0.8766
10	San Francisco	Trespass	77%	Trespass	62%	Trespass	79%	Trespass	77%
10	San Francisco	In x Years	2.30	In x Years	2.04	In x Years	1.89	In x Years	2.03
10	San Francisco	R2	0.8596		0.8545		0.8617		0.8625

USDNCPI = Annual Growth for Non-Rent CPI Components for the United States

DHPI = Local Annual Growth for Housing Price Index

DRCPI = Annual Growth for Rent in CPI for the Previous Quarter

{x} = Variable lagged "x" number of periods; taken from "x" previous periods (quarters)

APPENDIX C: SUMMARY OUTPUTS FOR REGRESSIONS BY MSA

Boston

Linear Regression - Estimation by Least Squares
Dependent Variable DRCPI
Panel(231) of Quarterly Data From 2//1978:02 To 2//2023:03
Usable Observations 175
Degrees of Freedom 171
Skipped/Missing (from 182) 7
Centered R^2 0.8451770
R-Bar^2 0.8424608
Uncentered R^2 0.9516339
Mean of Dependent Variable 0.0429330204
Std Error of Dependent Variable 0.0290214777
Standard Error of Estimate 0.0115189757
Sum of Squared Residuals 0.0226894431
Regression F(3,171) 311.1623
Significance Level of F 0.0000000
Log Likelihood 534.8669
Durbin-Watson Statistic 2.3626

	Variable	Coeff	Std Error	T-Stat	Signif
1	Constant	0.004494434	0.001569406	2.86378	0.00471055
2	USDNCPI{4}	0.149339675	0.029547296	5.05426	0.0000011
3	DHPI{4}	0.066234705	0.015633612	4.23669	0.000037
4	DRCPI{1}	0.678118947	0.048713355	13.9206	0

Chicago

Linear Regression - Estimation by Least Squares
Dependent Variable DRCPI
Panel(231) of Quarterly Data From 3//1978:02 To 3//2023:03

Usable Observations	182
Degrees of Freedom	178
Centered R^2	0.7978633
R-Bar^2	0.7944565
Uncentered R^2	0.9658943
Mean of Dependent Variable	0.0395061313
Std Error of Dependent Variable	0.0178475928
Standard Error of Estimate	0.0080915465
Sum of Squared Residuals	0.0116542161
Regression F(3,178)	234.1974
Significance Level of F	0.0000000
Log Likelihood	620.4577
Durbin-Watson Statistic	2.3726

	Variable	Coeff	Std Error	T-Stat	Signif
1	Constant	0.004962704	0.001476978	3.36004	0.00095351
2	USDNCPI{1}	0.086944165	0.020221186	4.29966	0.00002814
3	DHPI{1}	0.024598686	0.010795617	2.27858	0.02387994
4	DRCPI{1}	0.775771537	0.040894704	18.96998	0

Dallas

Linear Regression - Estimation by Least Squares
Dependent Variable DRCPI
Panel(231) of Quarterly Data From 4//1978:02 To 4//2023:03

Usable Observations	182
Degrees of Freedom	178
Centered R^2	0.8526376
R-Bar^2	0.8501540
Uncentered R^2	0.9365966
Mean of Dependent Variable	0.0405169698
Std Error of Dependent Variable	0.0353066243
Standard Error of Estimate	0.0136671763
Sum of Squared Residuals	0.0332489239
Regression F(3,178)	343.3022
Significance Level of F	0.0000000
Log Likelihood	525.0575
Durbin-Watson Statistic	2.1710

	Variable	Coeff	Std Error	T-Stat	Signif
1	Constant	0.001922921	0.00164971	1.16561	0.24533113
2	USDNCPI	0.071106217	0.032725068	2.17284	0.03111423
3	DHPI	0.092570074	0.021725396	4.26092	0.00003294
4	DRCPI{1}	0.777481949	0.037136925	20.93555	0

Detroit

Linear Regression - Estimation by Least Squares
Dependent Variable DRCPI
Panel(231) of Quarterly Data From 5//1978:02 To 5//2023:03

Usable Observations	182
Degrees of Freedom	178
Centered R^2	0.8107997
R-Bar^2	0.8076109
Uncentered R^2	0.9403852
Mean of Dependent Variable	0.0344297683
Std Error of Dependent Variable	0.0234169069
Standard Error of Estimate	0.0102711655
Sum of Squared Residuals	0.0187784378
Regression F(3,178)	254.2673
Significance Level of F	0.0000000
Log Likelihood	577.0470
Durbin-Watson Statistic	1.9850

	Variable	Coeff	Std Error	T-Stat	Signif
1	Constant	0.003900951	0.00136538	2.85704	0.00478551
2	USDNCPI	0.055080775	0.026912652	2.04665	0.04216277
3	DHPI	0.032757319	0.012015883	2.72617	0.00704808
4	DRCPI{1}	0.7891499	0.044096095	17.89614	0

Houston

Linear Regression - Estimation by Least Squares
Dependent Variable DRCPI
Panel(231) of Quarterly Data From 6//1978:02 To 6//2023:03

Usable Observations	182
Degrees of Freedom	178
Centered R^2	0.7512958
R-Bar^2	0.7471042
Uncentered R^2	0.8750336
Mean of Dependent Variable	0.0338917686
Std Error of Dependent Variable	0.0341535677
Standard Error of Estimate	0.0171754023
Sum of Squared Residuals	0.0525090112
Regression F(3,178)	179.2366
Significance Level of F	0.0000000
Log Likelihood	483.4739
Durbin-Watson Statistic	2.4182

	Variable	Coeff	Std Error	T-Stat	Signif
1	Constant	0.001268044	0.002005491	0.63229	0.52801117
2	USDNCPI{2}	0.138976429	0.040002652	3.47418	0.0006435
3	DHPI{2}	0.074894411	0.031999837	2.34046	0.02036803
4	DRCPI{1}	0.729638691	0.048165557	15.14856	0

Los Angeles

Linear Regression - Estimation by Least Squares
Dependent Variable DRCPI
Panel(231) of Quarterly Data From 7//1978:02 To 7//2023:03

Usable Observations	180
Degrees of Freedom	176
Skipped/Missing (from 182)	2
Centered R^2	0.9262893
R-Bar^2	0.9250329
Uncentered R^2	0.9781345
Mean of Dependent Variable	0.0463696542
Std Error of Dependent Variable	0.0301973724
Standard Error of Estimate	0.0082680780
Sum of Squared Residuals	0.0120315562
Regression F(3,176)	737.2378
Significance Level of F	0.0000000
Log Likelihood	609.7772
Durbin-Watson Statistic	2.4519

	Variable	Coeff	Std Error	T-Stat	Signif
1	Constant	0.001303331	0.001144415	1.13886	0.25630855
2	USDNCPI	0.058469647	0.020166142	2.8994	0.0042152
3	DHPI	0.015427981	0.006526398	2.36394	0.01917218
4	DRCPI{1}	0.903300175	0.023957864	37.7037	0

Miami

Linear Regression - Estimation by Least Squares
Dependent Variable DRCPI
Panel(231) of Quarterly Data From 8//1978:02 To 8//2023:03
Usable Observations 179
Degrees of Freedom 175
Skipped/Missing (from 182) 3
Centered R^2 0.8612050
R-Bar^2 0.8588257
Uncentered R^2 0.9394739
Mean of Dependent Variable 0.0429775122
Std Error of Dependent Variable 0.0378995741
Standard Error of Estimate 0.0142400729
Sum of Squared Residuals 0.0354864433
Regression F(3,175) 361.9508
Significance Level of F 0.0000000
Log Likelihood 509.0861
Durbin-Watson Statistic 2.2815

	Variable	Coeff	Std Error	T-Stat	Signif
1	Constant	0.000192544	0.001730125	0.11129	0.91151459
2	USDNCPI	0.114898198	0.034485974	3.33174	0.00105294
3	DHPI	0.063647008	0.011679	5.4497	0.00000017
4	DRCPI{1}	0.824188025	0.032295869	25.51992	0

New York

Linear Regression - Estimation by Least Squares
Dependent Variable DRCPI
Panel(231) of Quarterly Data From 9//1978:02 To 9//2023:03

Usable Observations	182
Degrees of Freedom	178
Centered R^2	0.8751456
R-Bar^2	0.8730413
Uncentered R^2	0.9805244
Mean of Dependent Variable	0.0411798255
Std Error of Dependent Variable	0.0177521011
Standard Error of Estimate	0.0063252972
Sum of Squared Residuals	0.0071216705
Regression F(3,178)	415.8870
Significance Level of F	0.0000000
Log Likelihood	665.2776
Durbin-Watson Statistic	2.2258

	Variable	Coeff	Std Error	T-Stat	Signif
1	Constant	0.003747374	0.001204532	3.11106	0.00217174
2	USDNCPI{2}	0.062161514	0.014607284	4.25551	0.00003367
3	DHPI{2}	0.027487672	0.007295058	3.76799	0.00022357
4	DRCPI{1}	0.814844995	0.032639955	24.96465	0

Philadelphia

Linear Regression - Estimation by Least Squares
Dependent Variable DRCPI
Panel(231) of Quarterly Data From 10//1978:02 To 10//2023:03

Usable Observations	180
Degrees of Freedom	176
Skipped/Missing (from 182)	2
Centered R^2	0.8795417
R-Bar^2	0.8774885
Uncentered R^2	0.9687170
Mean of Dependent Variable	0.0379686439
Std Error of Dependent Variable	0.0225510535
Standard Error of Estimate	0.0078932406
Sum of Squared Residuals	0.0109653714
Regression F(3,176)	428.3623
Significance Level of F	0.0000000
Log Likelihood	618.1284
Durbin-Watson Statistic	2.3449

	Variable	Coeff	Std Error	T-Stat	Signif
1	Constant	0.001710002	0.001174686	1.45571	0.14725433
2	USDNCPI{1}	0.077415271	0.018488797	4.18714	0.00004458
3	DHPI{1}	0.02760748	0.012015351	2.29768	0.02275647
4	DRCPI{1}	0.850932749	0.031566687	26.95667	0

San Francisco

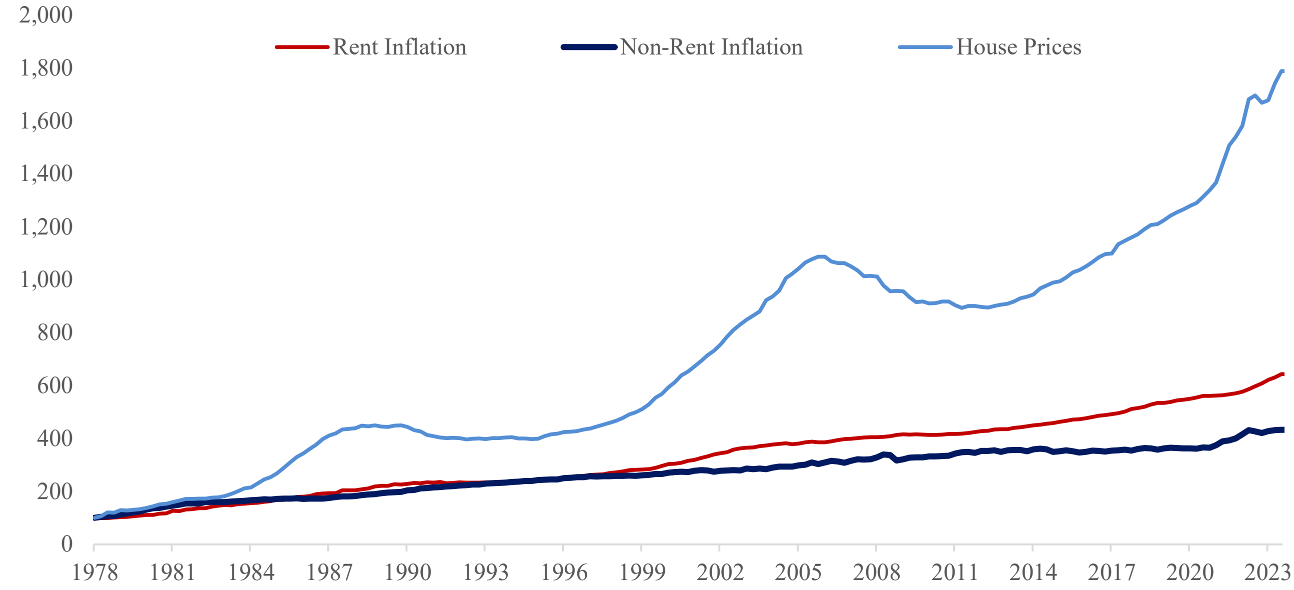
Linear Regression - Estimation by Least Squares
Dependent Variable DRCPI
Panel(231) of Quarterly Data From 11//1978:02 To 11//2023:03

Usable Observations	182
Degrees of Freedom	178
Centered R^2	0.8617196
R-Bar^2	0.8593891
Uncentered R^2	0.9562315
Mean of Dependent Variable	0.0482792585
Std Error of Dependent Variable	0.0329454048
Standard Error of Estimate	0.0123539087
Sum of Squared Residuals	0.0271661926
Regression F(3,178)	369.7466
Significance Level of F	0.0000000
Log Likelihood	543.4440
Durbin-Watson Statistic	2.0993

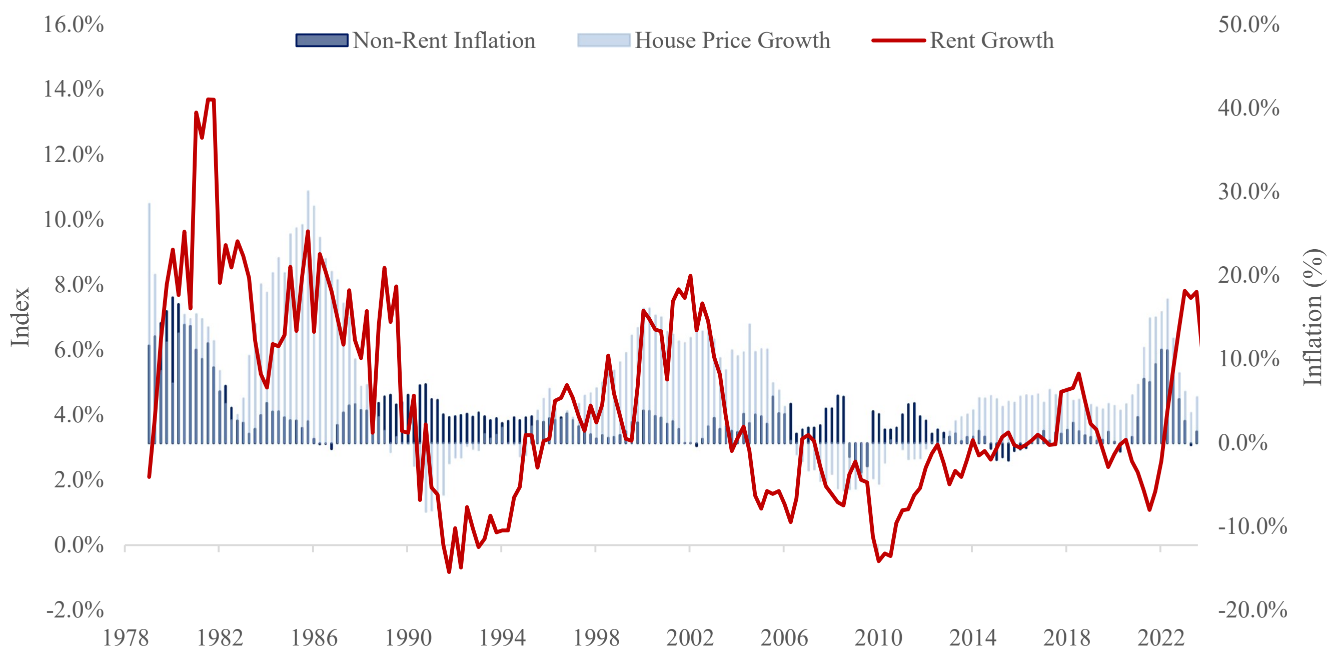
	Variable	Coeff	Std Error	T-Stat	Signif
1	Constant	0.00182005	0.001708816	1.06509	0.28827583
2	USDNCPI{2}	0.080540614	0.028106494	2.86555	0.00466436
3	DHPI{2}	0.024180988	0.01096828	2.20463	0.02876213
4	DRCPI{1}	0.867405329	0.031078403	27.91023	0

APPENDIX D: GRAPHS BY METROPOLITAN STATISTICAL AREA

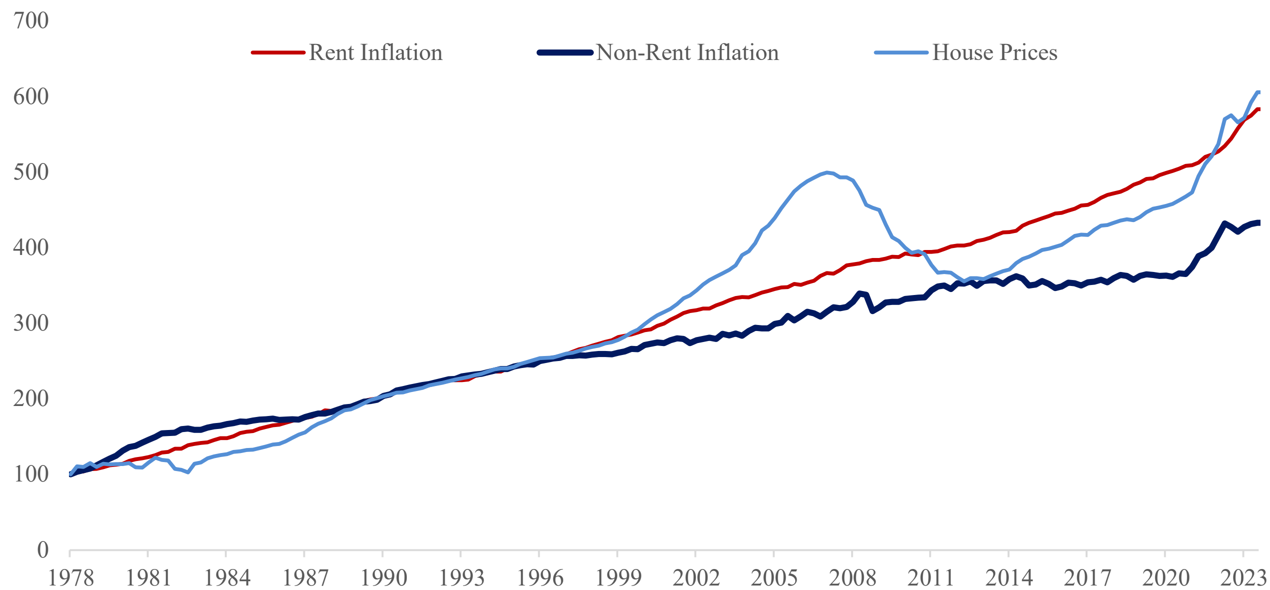
Graph 14. Boston: Index for House Prices, NR Inflation, and Rents



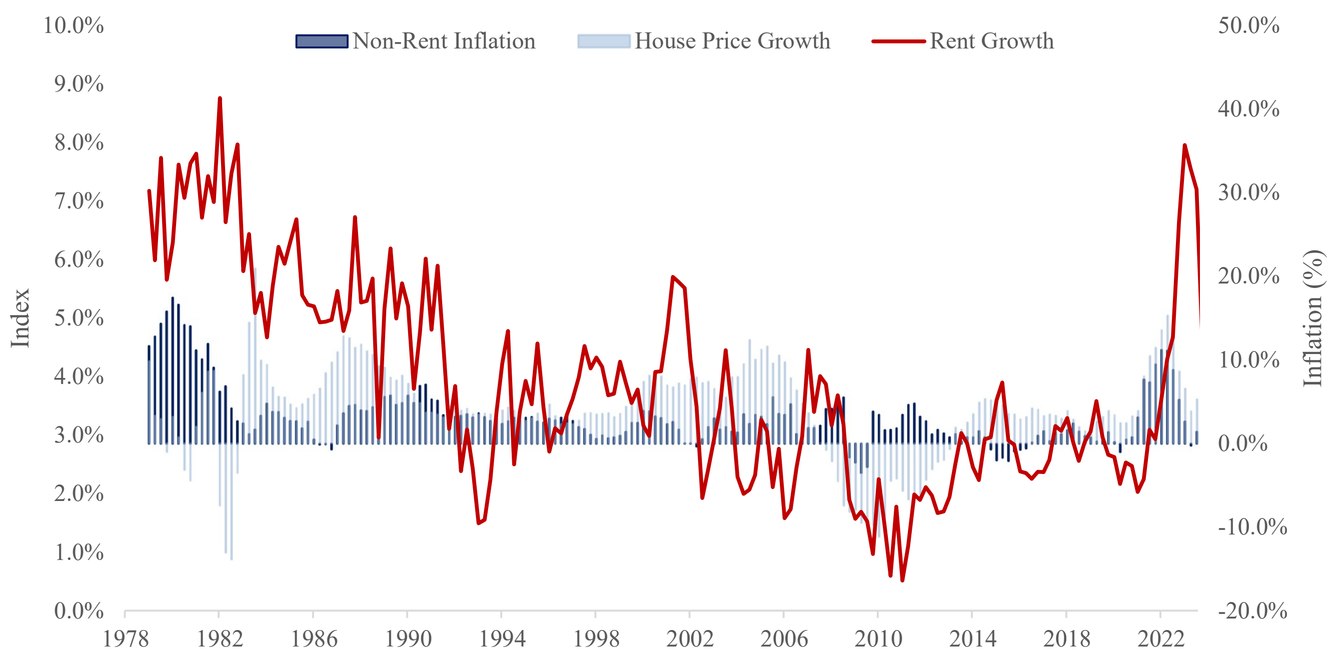
Graph 15. Boston: Annual Rent Growth v. HPI Growth & NR Inflation



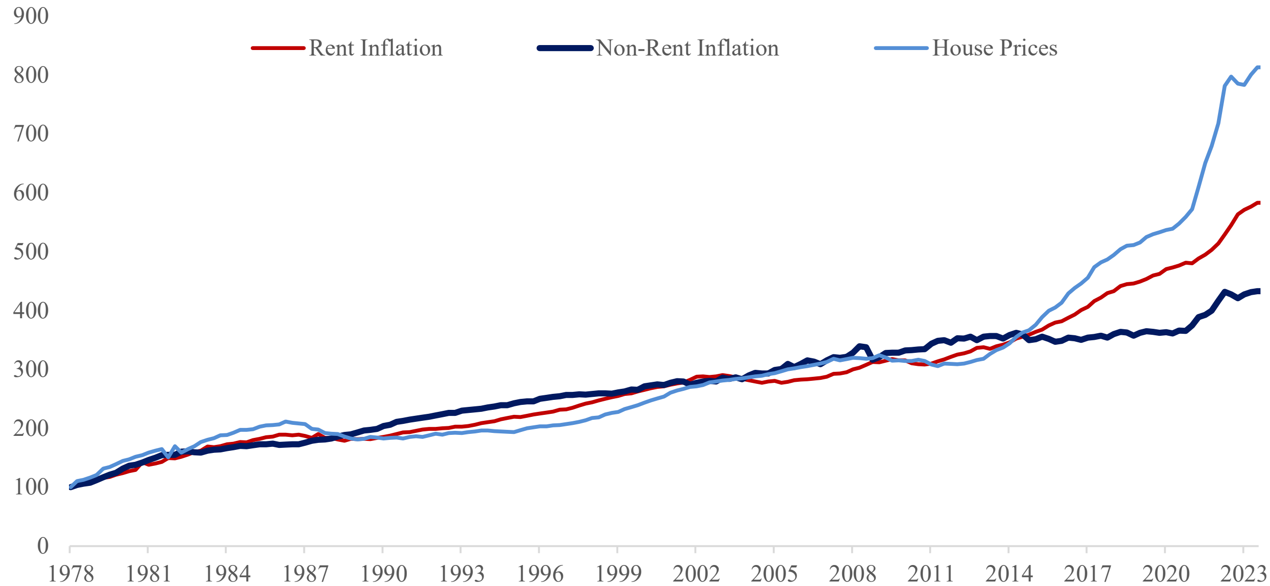
Graph 16. Chicago: Index for House Prices, NR Inflation, and Rents



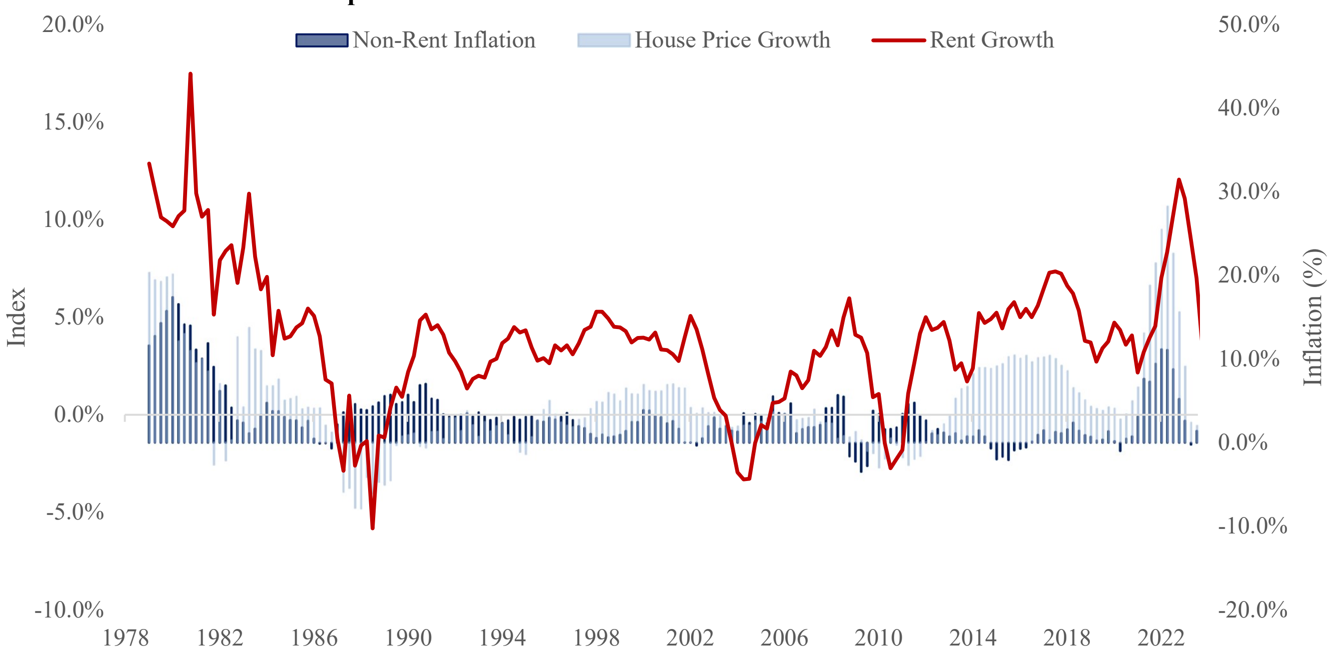
Graph 17. Chicago: Annual Rent Growth v. HPI Growth & NR Inflation



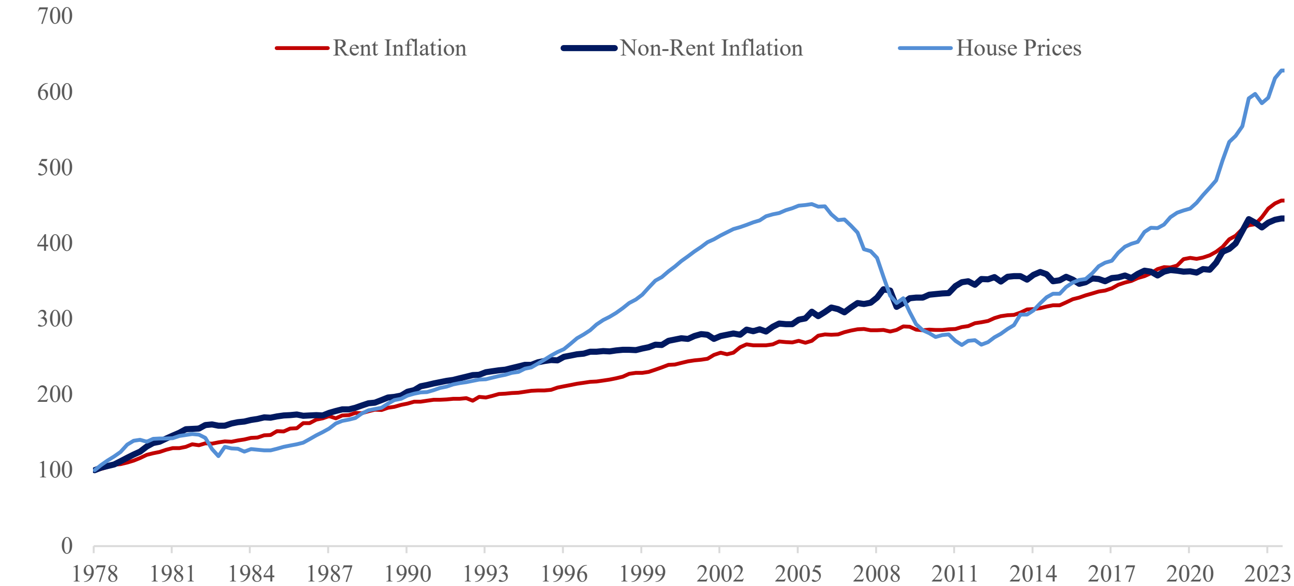
Graph 18. Dallas: Index for House Prices, NR Inflation, and Rents



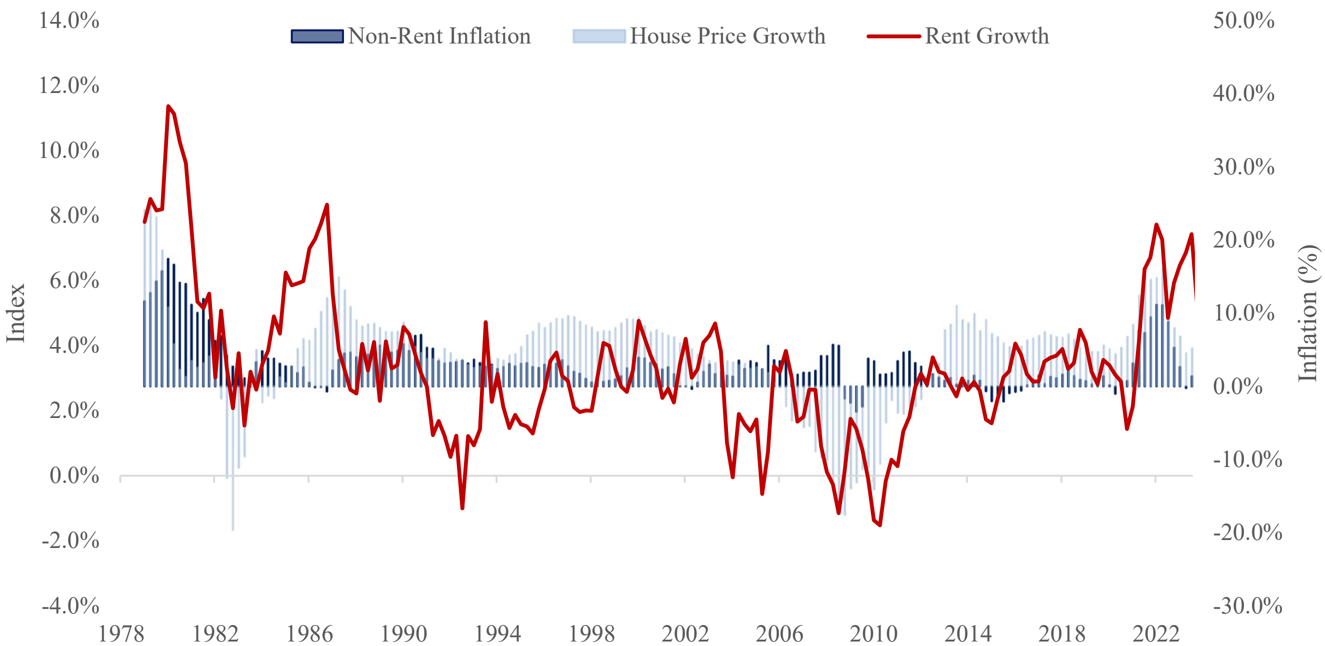
Graph 19. Dallas: Annual Rent Growth v. HPI Growth & NR Inflation



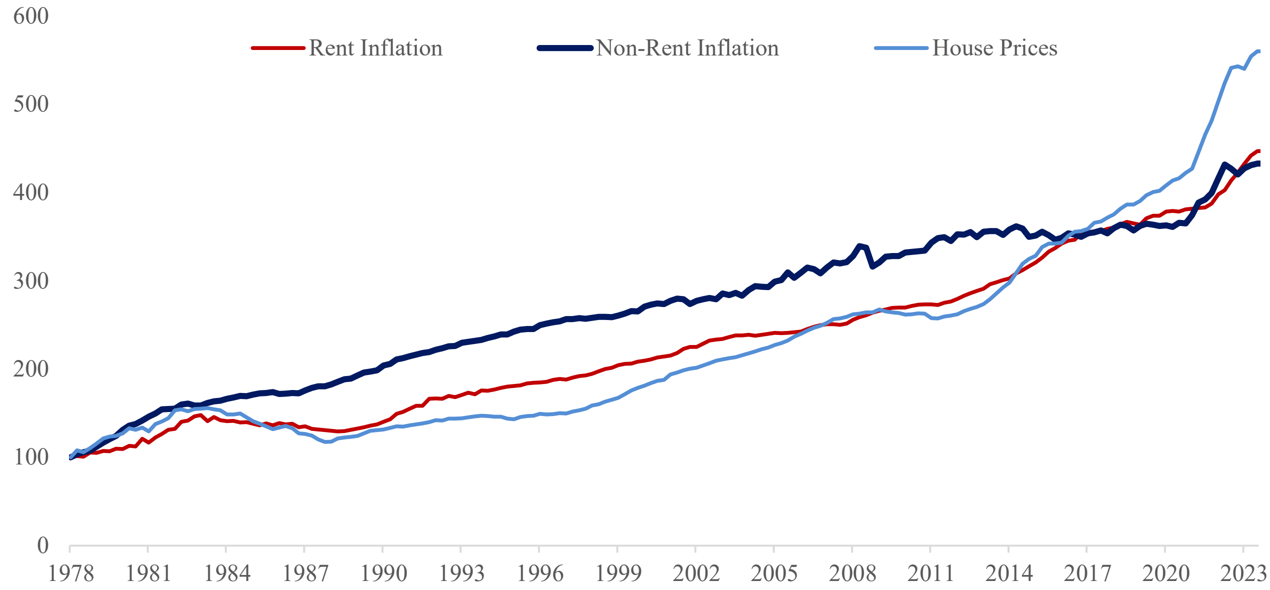
Graph 20. Detroit: Index for House Prices, NR Inflation, and Rents



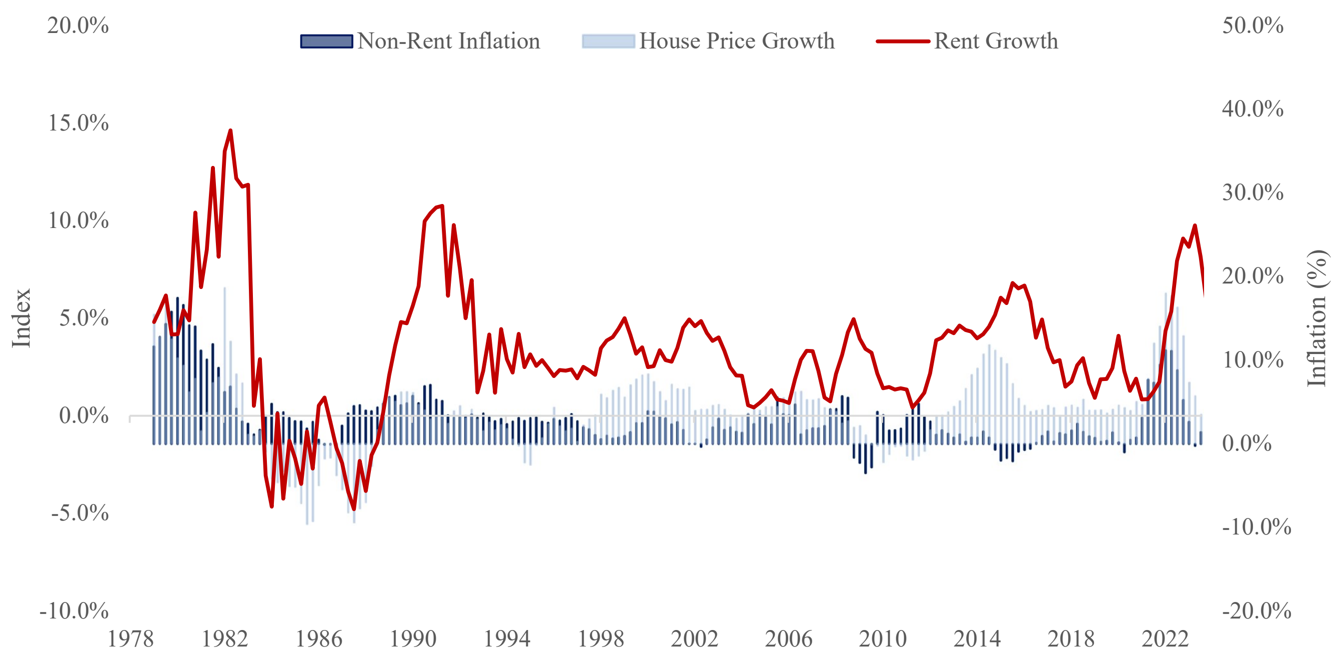
Graph 21. Detroit: Annual Rent Growth v. HPI Growth & NR Inflation



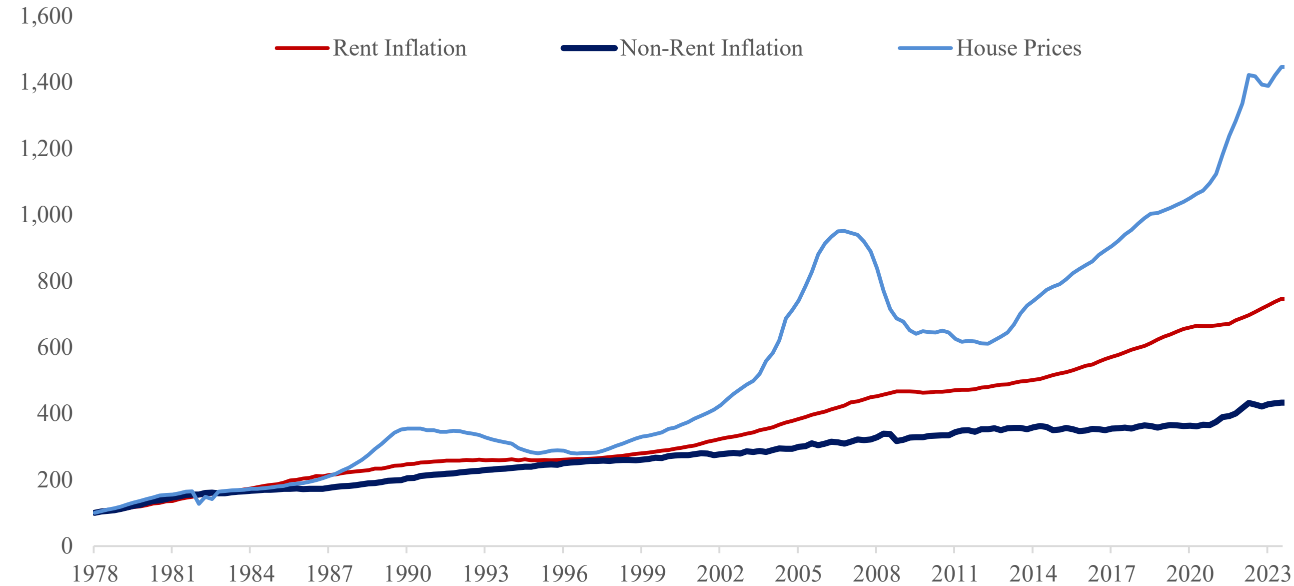
Graph 22. Houston: Index for House Prices, NR Inflation, and Rents



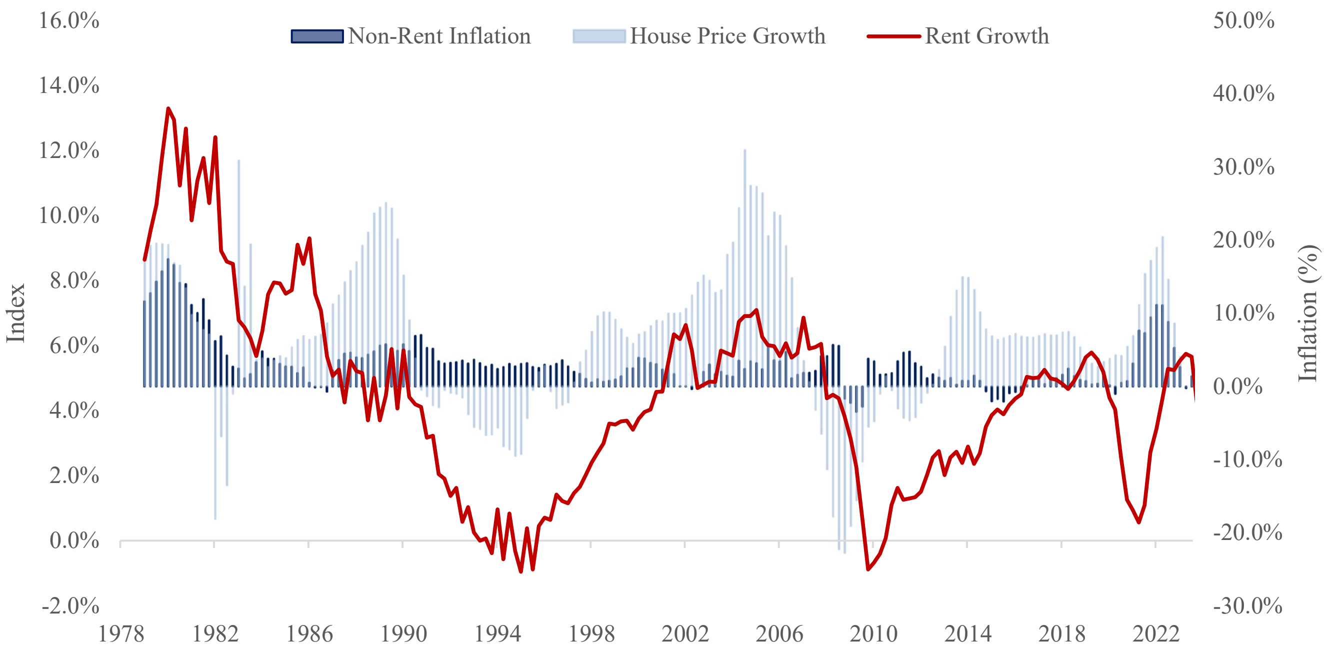
Graph 23. Houston: Annual Rent Growth v. HPI Growth & NR Inflation



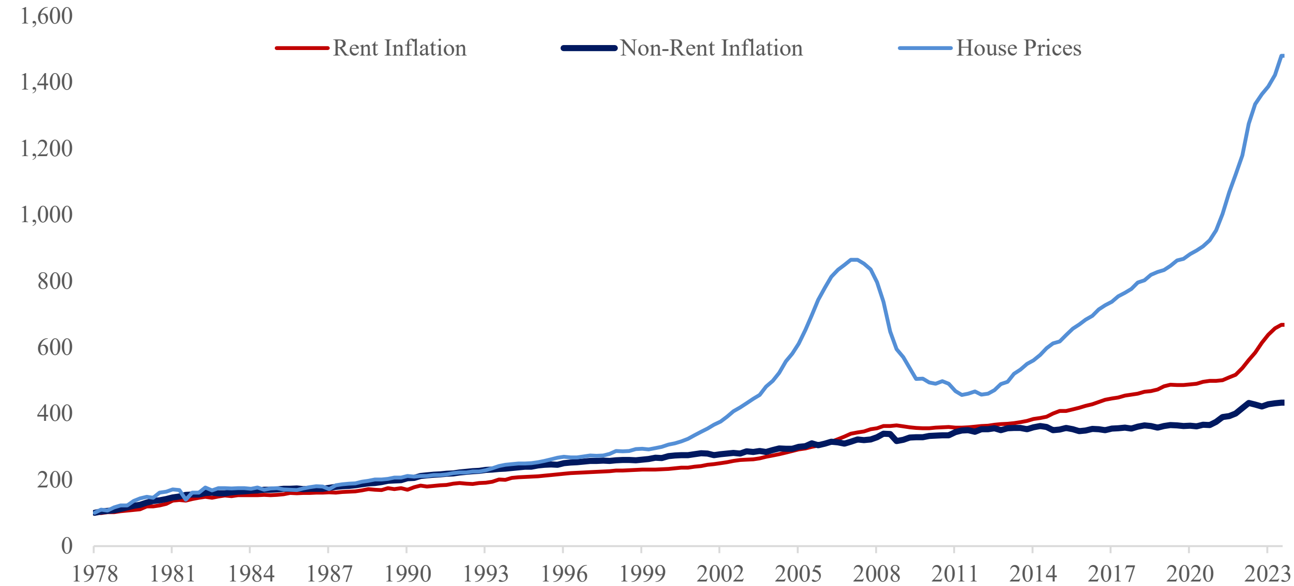
Graph 24. Los Angeles: Index for House Prices, NR Inflation, and Rents



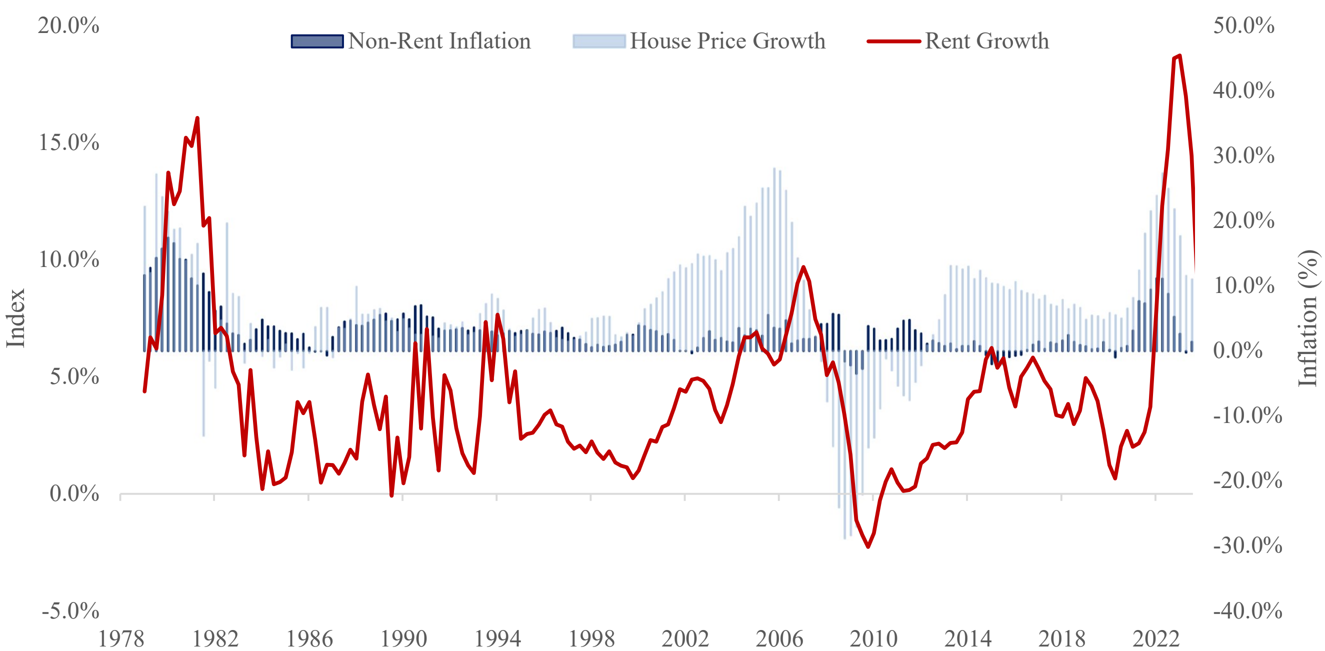
Graph 25. Los Angeles: Annual Rent Growth v. HPI Growth & NR Inflation



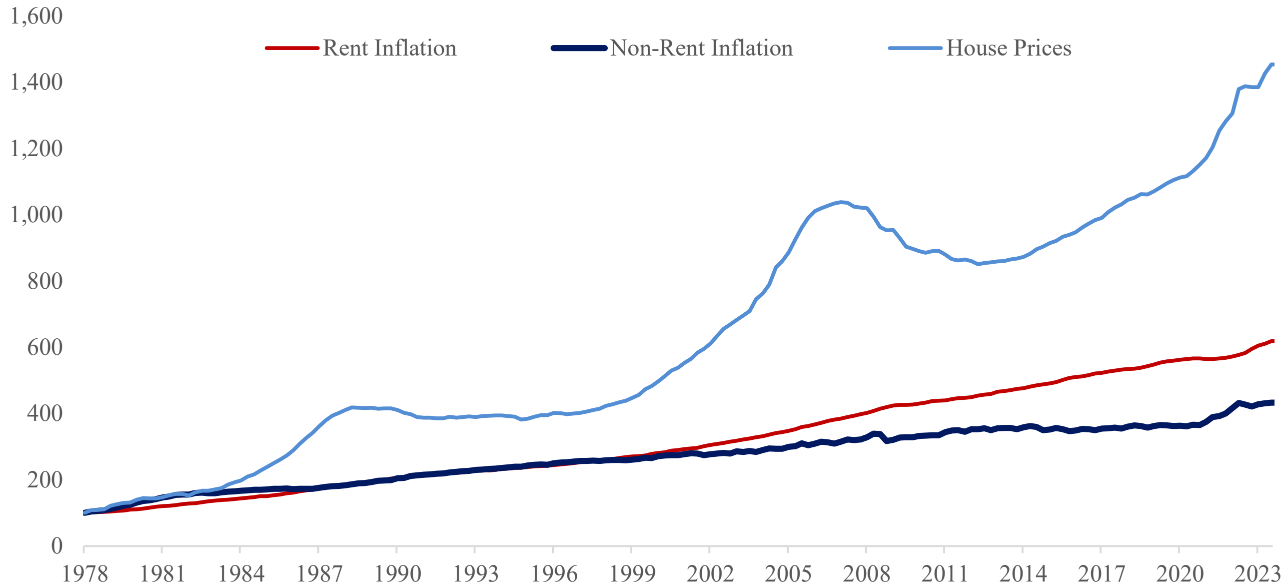
Graph 26. Miami: Index for House Prices, NR Inflation, and Rents



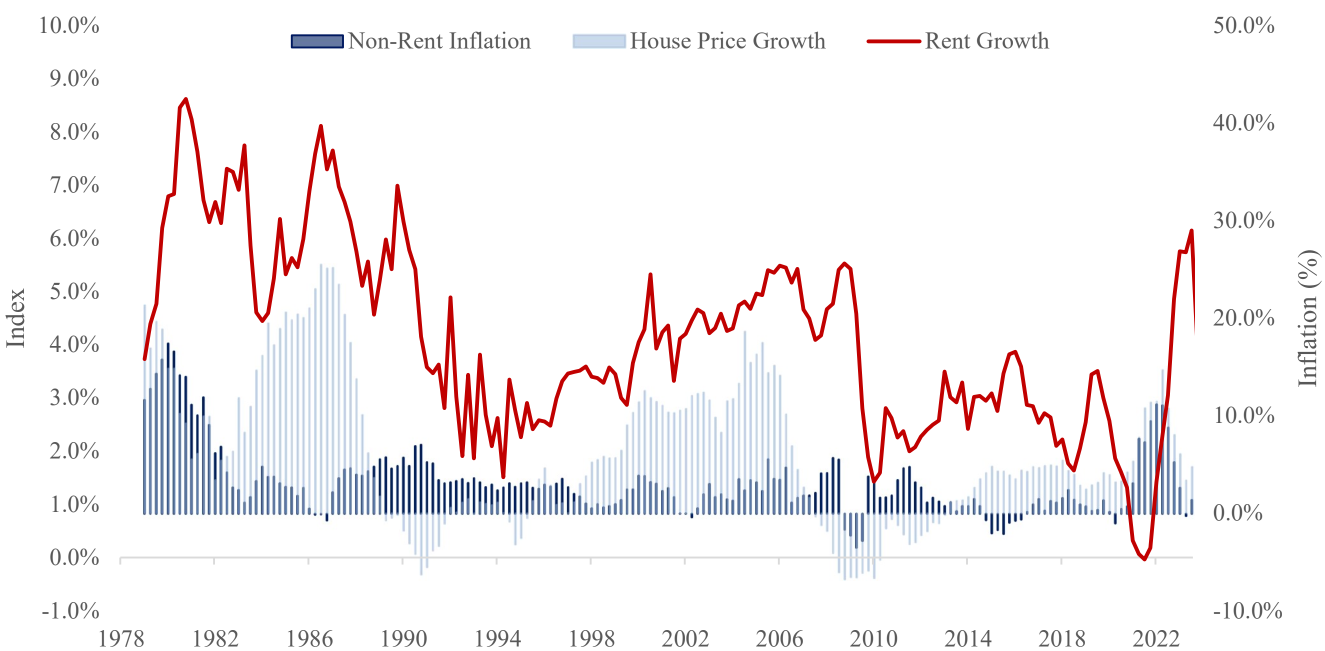
Graph 27. Miami: Annual Rent Growth v. HPI Growth & NR Inflation



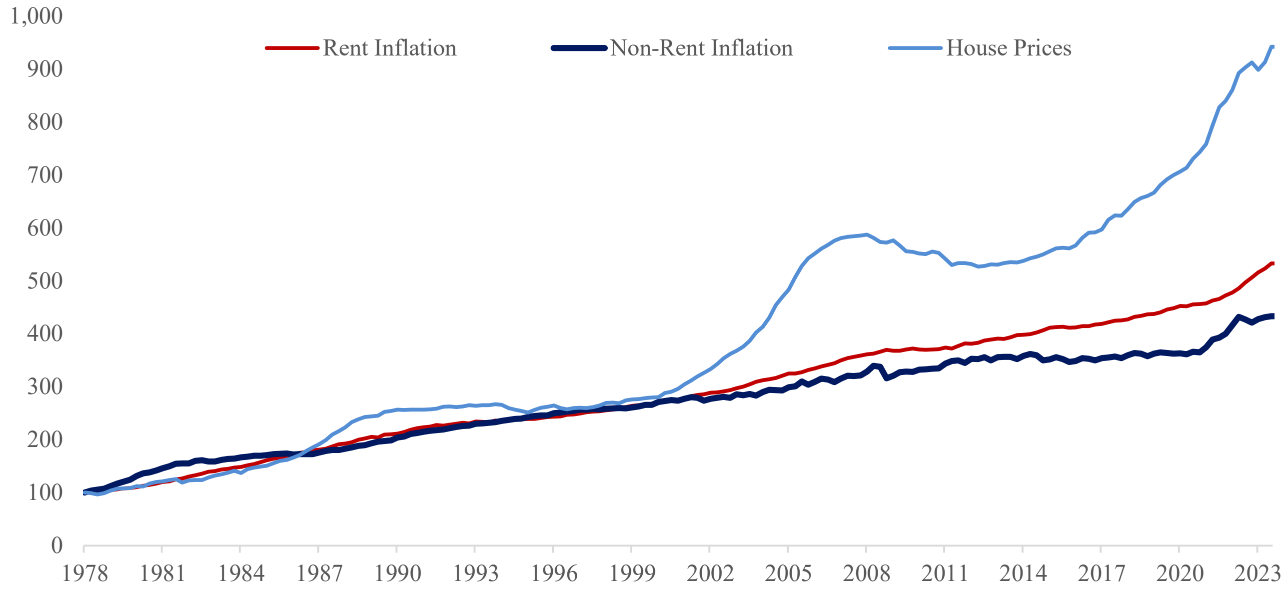
Graph 28. New York: Index for House Prices, NR Inflation, and Rents



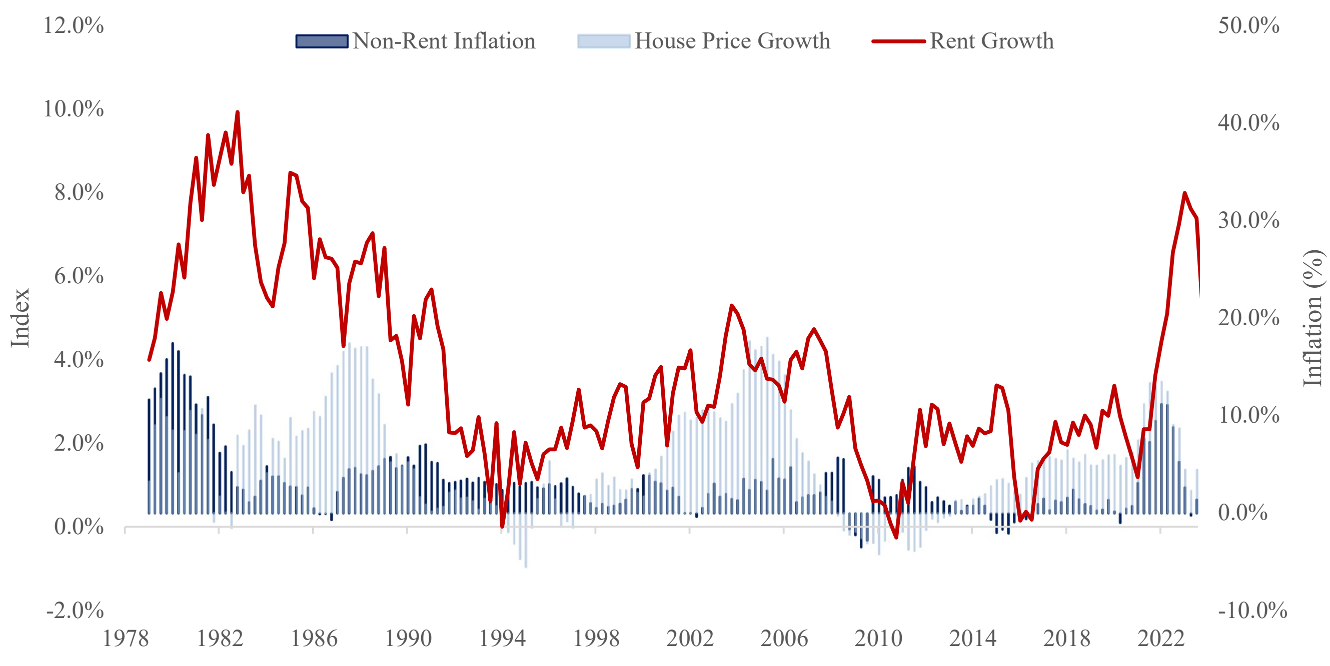
Graph 29. New York: Annual Rent Growth v. HPI Growth & NR Inflation



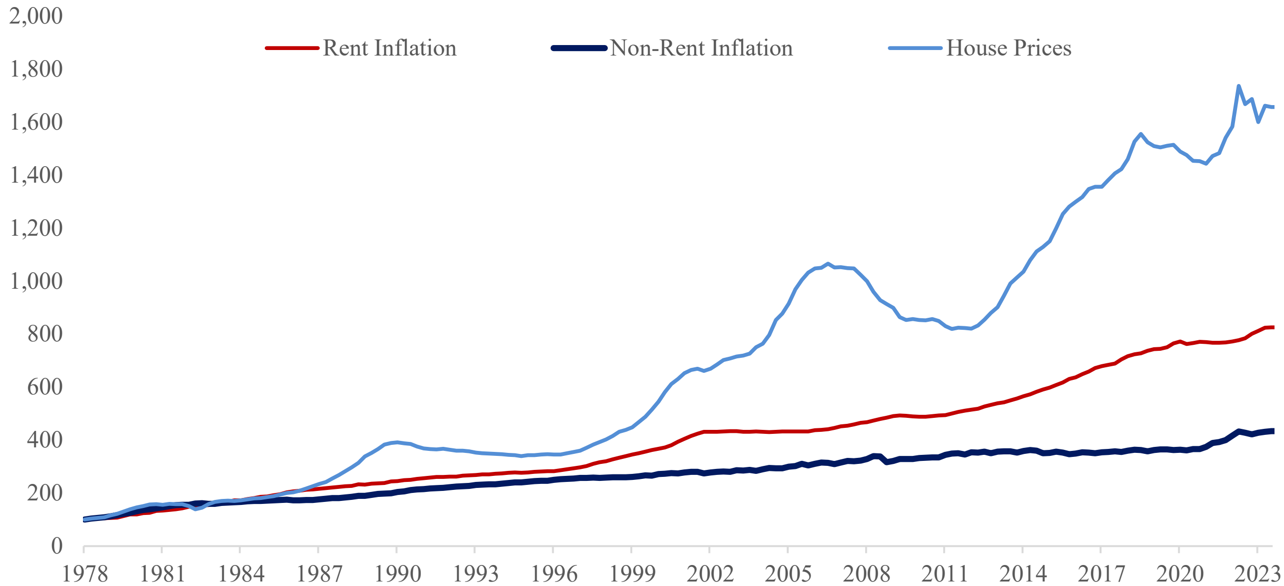
Graph 30. Philadelphia: Index for House Prices, NR Inflation, and Rents



Graph 31. Philadelphia: Annual Rent Growth v. HPI Growth & NR Inflation



Graph 32. San Francisco: Index for House Prices, NR Inflation, and Rents



Graph 33. San Francisco: Annual Rent Growth v. HPI Growth & NR Inflation