# Monetary Policy and Gentrification: the Cost Channel*

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**Abstract**

This paper highlights the link between monetary policy and the dislocation of low-income households from desirable locations (gentrification). Specifically, property values and the share of educated residents increased more in desirable locations (e.g., city centers) than in less desirable locations during periods of monetary-policy-induced national-housing-market expansions. This difference-in-differences holds conditional on changes in local income. To interpret this evidence, I present a model in which expansionary monetary policy causes a decline in the cost of living in desirable areas for high-income households (relative to the cost for low-income households). The evidence adds to a list of unintended consequences of monetary policy.

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# 1 Introduction

The strong monetary response necessary to combat recessions over the past couple of decades has raised concerns about unintended consequences. Concerns about distributional effects in particular have prompted a re-evaluaton of the objectives of macroeconomic policy (e.g., Bernanke (2015)) and prompted research exploring the link between monetary policy and inequality (e.g., Coibion et al. (2017), Beraja et al. (2018), Auclert (2019)).

A seemingly unrelated concern has been the trend of rising property values and displacement of low-income households in downtown neighborhoods and other desirable locations (gentrification) over the past few decades (e.g., Baum-Snow and Hartley (2019), Couture and Handbury (2019)).[1] Much of the work examining causes and consequences of gentrification has focused on slow-moving forces such as rising incomes shares among educated households and has abstracted from higher-frequency macroeconomic policy changes. Yet monetary policy and housing markets are intricately linked, and gentrification is a potential candidate for unintended consequences of monetary policy.

How has monetary policy contributed to gentrification, if at all? A priori the effect of monetary policy on gentrification is not clear. Expansionary monetary policy lowers borrowing costs for homebuyers and developers. These lower borrowing costs - conditional on household income - could disproportionately accelerate new suburban developments for medium-to-high-income households, thus slowing the pace of gentrification. Alternatively, lower borrowing costs could disproportionately lower costs of redeveloping low-income neighborhoods in the city center, thus accelerating gentrification.

Isolating a causal link between monetary policy and gentrification is challenging due to the high-frequency effects of monetary policy and the low frequency and limited sample for which measures of gentrification are available. The primary metric of gentrification - shares of high-income households - is available for detailed levels of economic geography only during census years or only annually as of 2005, thus posing a substantial identification challenge.

In this paper I exploit patterns in monetary policy since 2000 to overcome the challenge of limited data on income shares across locations. I document that the effect of monetary policy on property markets has undergone cycles of approximately five years duration. During periods of monetary expansion and rising national home values, more desirable locations (e.g., neighborhoods near city centers) experience larger increases in high-income-resident shares and property values than do less desirable locations. These patterns are evident

[1]Recent estimates imply that gentrification has led to lower welfare for low-income households (Couture et al. (2019)).More generally, there can be large externalities associated with the spatial re-distribution of households (e.g., Chetty et al. (2016), Chyn (2018), Fu and Gregory (2019)).

both within metropolitan areas (comparing city centers to suburbs) and across metropolitan areas (comparing higher-amenity metropolitan areas to lower-amenity metropolitan areas). The across-location differences in changes in bachelors shares and property values hold conditional on metropolitan area income growth, which suggests that mechanisms related to monetary policy-induced cost reductions, rather than income expansions, are responsible for the patterns in the data.

To guide the interpretation of the empirical evidence, I present a model that formalizes the conditions under which lower interest rates (conditional on household incomes) lead to migration of high-income households toward desirable locations (e.g., downtown-adjacent neighborhoods), a rise property values in those locations, and displacement of low-income residents. To emphasize that monetary policy operates alongside other long-term drivers of gentrification, I refer to the effect of expansionary (contractionary) monetary policy on gentrification as acceleration (deceleration). The model predicts that expansionary policy causes acceleration when lower interest rates disproportionately lower the cost of living in desirable areas for high-income households. Since the empirical analysis and the theory condition on household income, I refer to this mechanism as the cost channel of monetary policy on gentrification.

In more detail, the baseline empirical analysis exploits the fact that monetary policy in the past decades has been characterized by staggered intervals (approximately five years in length) of expansionary and then contractionary periods. Monetary policy shocks affect housing markets with a delay, with a peak effect occurring around three years after the shock. I isolate home price movements that are attributed to monetary policy shocks and document that expansionary monetary shocks in the early 2000s caused home prices to appreciate between 2000 and 2005. Contractionary monetary policy in the mid-2000s caused home prices to decline substantially on net between 2005 and 2010. Over the subsequent five years (2010 to 2015), expansionary monetary policy pushed up home prices. To help isolate any potentially confounding factors associated with the global financial crisis of 2008 (GFC) and its aftermath, I also examine subperiods prior to 2008.

These staggered intervals of policy-induced home price appreciation and depreciation permit inference of the effect of monetary policy through a difference-in-differences (DiD) analysis. In particular, I examine the differential change in gentrification metrics between more-desirable (e.g., downtown areas) and less-desirable economic geographies during periods of monetary expansion versus periods of monetary contraction. The analysis controls for total income growth in a metropolitan area, thus limiting the extent to which non-monetary factors (or even monetary factors operating through income rather than directly through borrowing costs) can account for the differential changes.

I examine two independent classifications of location desirability. First, I examine *within-city* differences between downtown areas and suburban neighborhoods. Downtown areas are desirable due to consumption amenities that are typically found in city centers (e.g, Glaeser et al. (2001), Couture and Handbury (2019)) and due to residents' proximity to their place of work. The second classification of desirability is based on *across-city* differences in natural amenities. More-desirable locations are those with higher amenity scores from the United States Department of Agriculture Economic Research Service's (USDA ERS) natural amenities scale.

Using U.S. Census data organized by the Integrated Public Use Microdata Study (IPUMS, Steven Ruggles and Sobek (2020)), I find that central cities of metropolitan statistical areas (MSAs) exhibit larger increases in the share of residents with a bachelors degree during expansionary monetary periods than do suburbs of MSAs. The implied effect of monetary policy is economically substantial: the difference in differences (0.028) is 20% larger than the average 5-year change in bachelors shares within central cities (0.023). The IPUMS data also contains information on home rental prices paid by survey respondents. I find a similar pattern for rental price growth, and with an economically substantial baseline DiD coefficient of 9.2%.

The same patterns holds when comparing changes in high-amenity MSAs to changes in other MSAs, with similarly large implied effects. The change in the share of residents with a bachelors degree in high-amenity MSAs compared to low-amenity MSAs during expansionary monetary periods (compared to contractionary monetary periods) is as large as the average five-year change in bachelors shares across MSAs. Rental price growth exhibits a similarly large DiD coefficient (13%).

To complement the analysis using IPUMS data, I also examine zip-code-level home price and rental price data from Zillow. The localized nature of this data permits alternative classifcations of desirability across locations within MSAs (rather than being confined to comparing central cities to suburbs as in the IPUMS data) [2] I classify desirable zip codes near city centers using a similar procedure to that in Couture et al. (2019) and Holian et al. (2012). The DiD analysis of the Zillow data produces similar (and more precise) inference to that using the IPUMS data, both when examining differences in desirability within cities (based on proximity to downtown) and when examining differences across MSAs (based on natural amenities). For example, the baseline within-MSA DiD coefficient (0.08) is over half the average 5-year growth in the Zillow home price index across MSAs (0.13). The across-MSA DiD coefficient (0.49) is nearly four times as large.

An advantage of the Zillow data is that it is available at the localized level consistently since 2000, thus permitting an analysis based on shorter time periods that exclude the GFC.[3]

[2]The most localized information in the IPUMS data is the public use mircrodata (PUMA) of respondents and whether the respondent lives in the Central City of the MSA. PUMA boundaries change, often times significantly, across sample periods. Therefore, the construction of desirable within-city locations is restricted to differences in central city status.

[3]In contrast, IPUMS data only contain city-level information in 2000 and then from 2005 onward.

As a robustness check, I use the Zillow data to compare differences between the monetary-policy-induced national housing market expansion from 2003 to 2005 and the contraction from 2005 to 2007. The results are similar to those from the analysis that includes the GFC.

As a final and independent test of the theory's predictions, I use identified monetary policy shocks (the updated Romer and Romer (2004) shocks from Coibion et al. (2017)) to examine the differential impulse responses of housing markets across MSAs. To account for potential differences in income effects of MP across location, I normalize home prices by local income. The theory and the prior DiD analysis imply that home prices (relative to income) should respond more to a monetary policy shock in MSAs with high levels of natural amenities than in MSAs with low levels of natural amenities. This is exactly the pattern I document in the MSA-level impulse response functions. Housing markets in high-natural-amenity MSAs (e.g., San Diego and Miami) are far more responsive to monetary policy than housing markets in low-natural-amenity MSAs (e.g., Detroit, Cleveland, Minneapolis).

To formalize a mechanism that can account for this evidence, I present a theory in which two types of residents (high-income and low-income) sort into one of two locations of different desirability, each of which offers access to a valuable amenity. Residents of the less desirable location must pay a transportation cost to access the amenity, which represents the time cost of traveling to work or downtown amenities (when considering within-MSA differences in desirability) or the cost of traveling to high-natural-amenity locations (when considering across-MSA differences in desirability).[4]

I model expansionary monetary policy as a reduction in housing costs.[5] The model predicts that expansionary monetary policy induces gentrification when credit expansions disproportionately lower housing costs in desirable areas for high-income households. There are a number of reasons that high-income residents of desirable areas might benefit disproportionately from borrowing cost reductions. One is that high-income households have better access to credit and therefore interest-rate reductions pass through to high-income households' housing costs more so than they do to low-income households' housing costs.[6]

[4]The literature has identified a number of reasons that downtown areas might be more desirable beyond the traditional benefit of proximity to work (Mills (1967),Muth (1969)). These include a greater range of amenities and services in downtown areas (e.g., Glaeser et al. (2001); Couture and Handbury (2019); Baum-Snow and Hartley (2019); Murphy (2018)) and proximity to high-income residents (Guerrieri et al. (2013)). With regard to amenities, Lee and Lin (2018) document the importance of natural amenities for trends in the spatial distribution of income.

[5]This assumption is based on the observation that expansionary monetary policy lowers borrowing costs (e.g., Kuttner (2001); Gertler and Karadi (2015)) and increases credit supply (e.g., Bernanke and Gertler (1995); Jiménez et al. (2012)). Credit expansion is associated with increases in property values (e.g., Favara and Imbs (2015)). Recent theoretical work (e.g., Garriga et al. (2019)) formalizes the channel through which expansionary monetary policy lowers monthly borrowing costs, increases demand for loans, and increases housing prices.

[6]The notion that high-income residents disproportionately benefit from lower mortgage costs is consistent with evidence that low-income households are less likely to own homes (Goodman and Mayer (2018)) and that credit supply disproportionately flows to households with higher credit scores (Agarwal et al. (2017)).

This differential pass-through is stronger in desirable areas, which tend to have higher initial housing costs. Another is that high-income households consume higher quality housing material. As downtown land prices increase, there is less pass-through into per-unit housing costs for high-income households (consistent with the evidence in Bhutta et al. (2017)). As a result, high-income households demand relatively more housing in desirable areas. The net effect of these channels is an increase in desirable-location property values and a higher share of high-income residents.

I calibrate the model to match moments from 2000 Census data and I simulate a reduction in housing costs based on the reduction in average mortgage rates from the 2005-2010 period to the period between 2010 and 2015. The predicted difference between changes in the bachelors share in the desirable location and changes in the less-desirable location matches the baseline DiD coefficients (for both the within-MSA and across-MSA analyses) from the IPUMS data. The differential change in property values is also economically meaningful, with the magnitude of the change depending on whether or not lower interest rates directly translate into lower land rental prices.[7]

This paper is closely related to the literature discussed above on the distributional effects of monetary policy as well as the literature on causes of gentrification. It is also broadly related to the literature that examines the link between monetary policy and regional outcomes (e.g., Beraja et al. (2018), Hurst et al. (2016)). Beraja et al. (2018) document that regions with stronger equity positions as of 2008 responded more to interest rate cuts following the GFC. Their evidence linking equity collateral to housing market responses is related to an underlying assumption of my theoretical framework: interest rate reductions are of less benefit to low-income residents of downtown areas (e.g., due to low collateral and therefore low pass-though of the benefits of reduced interest rates).

The remainder of the paper proceeds as follows. Section 2 identifies periods of monetary-policy-induced housing market expansions and contractions. Section 3 presents empirical evidence. Section 4 presents a model that formalizes the link between the cost channel of monetary policy and gentrification. Section 5 concludes.

# 2 Monetary Policy and Housing Markets

Here I document that the link between monetary policy and housing markets since 2000 has exhibited distinct periods of approximately five years in duration. I will then exploit this cyclical relationship in the DiD analysis of Section 3.

[7] If land can be rented or sold, then the ownership cost of land (which varies with the interest rate) equals the rental cost of land. In that case, interest rate reductions cause much larger differential changes in land prices between downtown and suburban areas based on the different land supply elasticities across areas. Integration between owner-occupied housing and rental housing is consistent with the evidence in Gete and Reher (2018) of a link between costs of accessing credit for homeownership and rental prices.

Coibion et al. (2017) provide direct evidence of the link between monetary policy and housing prices, and report a strong housing price response to monetary policy shocks.[8] I use their definition of monetary policy shocks to characterize policy-dependent movements in home prices since 2000.

## 2.1 Monetary Policy Shocks Since 2000

Romer and Romer (2004) constructed an initial set of monetary policy (MP) shocks based on the component of policy changes at each FOMC meeting that is orthogonal to the information set of the Federal Reserve. Coibion et al. (2017) recently used their procedure to update the set of shocks through 2008. As they note, the 2000-2004 period was more expansionary than would be expected based on the Fed's forecasts of macroeconomic activity, and the subsequent few years was more contractionary.

Coibion et al. (2017) document the effects of these shocks on a range of macroeconomic variables, including housing prices, using the projection method of Jordá (2005). Here I estimate similar projections and use the estimates to derive the cumulative effect of monetary policy shocks on home prices over time. The updated Romer and Romer (2004) series is provided by Coibion et al. (2017). For home prices, I use the Case-Shiller national home price index, which is available on the FRED website starting in 1987. The first step is to estimate the response of home prices to the updated MP shocks at different horizons $h$:

$$x_{t+h} - x_{t+h-1} = C^h + \sum_{j=1}^{J} \alpha_j^h (x_{t-j} - x_{t-j-1}) + \sum_{i=1}^{I} \beta_i^h e_{t-1}^{RR} + \epsilon_{t+h}, \quad h = 0, ..., H \tag{1}$$

where $x$ is the natural logarithm of the Case-Shiller national home price index and $e_t^{RR}$ are the updated (quarterly) MP shocks. Figure 1 plots the reconstructed impulse response of home prices. A contractionary MP shock of 100 basis points causes home prices to decline substantially but with a long lag. After approximately three years, home prices have fallen by nearly 10%, and this decline persists for the subsequent couple of years.

With these impulse response estimates in hand, I derive the cumulative contribution of monetary policy shocks at each quarter $t$ (relative to some initial point $x_0$) by summing over the contribution of shocks at time $t-h, h \in \{0, ..., H\}$ to the contemporaneous change in log home prices $x_t - x_{t-1}$. The initial value for the home price index, along with cumulative sums of the implied changes, yields the cumulative contribution of monetary shocks to the

[8] Prior research supports the notion monetary policy affects housing markets. Monetary policy affects credit supply (e.g., Bernanke and Gertler (1995); Jiménez et al. (2012); Kuttner (2001)) and credit supply increases property values (e.g., Favara and Imbs (2015)). Garriga et al. (2019) explicitly model the link between monetary policy and housing prices. Expansionary monetary policy lowers interest payment costs of homeownership, thereby increasing demand for housing.

log level of home prices at each time $t$. Specifically,

$$X_t = x_0 + \sum_{s=0}^{t} \sum_{h=0}^{H} \hat{\beta}_1^h e_{t-s-h}^{RR}. \tag{2}$$

Equation 2 is the local projection analog of historical decompositions typically employed in analysis based on structural vector autoregressions.

Figure 2 plots the cumulative effect of monetary policy shocks on home prices (henceforth referred to as MP-induced home prices) between 2000 and 2015. There is a distinct interval of increasing MP-induced home prices between two periods of decreasing MP-induced home prices. Each of these periods is approximately five years in duration, with the first period beginning around 2000 and ending around 2005.

The timing of MP-induced home price changes tends to lag MP shocks due to the lag in the impulse response depicted in figure 1. For example, MP-induced home prices continued to rise shortly after 2005 even though monetary policy was contractionary as of 2005. Similarly, the MP shock series ends in 2008Q3, but MP-implied home prices subsequently increased into the 2010s. The figure does not account for the Fed's quantitative easing (QE) rounds of 2009, 2010, and 2012, which likely would have further contributed to the MP-induced home price appreciation between 2010 and 2015. Even without accounting for QE, it is clear that monetary policy contributed to rising home prices between 2010 and 2015.

Below I will exploit the timing of the transitions between different periods of MP-induced home prices to examine differences in gentrification metrics across economic geographies.

# 3 Empirical Analysis

Here I empirically examine the relationship between monetary policy and "gentrification metrics". These "gentrification metrics" include (1) the share of college-educated households in desirable locations, and (2) measures of property values. I examine both within-MSA differences in location desirability - based on proximity to downtown - as well as across-MSA differences based on natural amenities.

I conduct a series of empirical tests using different identification methodologies and different datasets. The primary source of identification is based on a difference-in-differences analysis that compares changes in gentrification metrics in desirable locations to changes in these metrics in less-desirable locations during periods of MP-induced national home price appreciation compared to periods of MP-induced national home price declines.

To isolate the housing cost channel of monetary policy from other channels and factors that operate through income, the DiD analysis controls for growth in MSA income. This tends to "over-control" for income changes in the analysis based on across-MSA differences in desirability, since MSA income is an endogenous response to residential sorting across MSAs in response to the cost channel of monetary policy. In the analysis based on within-MSA differences in desirability, this effectively controls for the primary other theoretical factor that (according to standard models of gentrification) drives within-MSA residential sorting.

The second identification strategy is to exploit the series of identified MP shocks. I compare the dynamic effect of monetary policy on housing markets in high-natural-amenity MSAs to the effect on housing markets in low-natural-amenity MSAs. Focusing on identified MP shocks isolates the source of home price changes. On its own, however, it does not isolate the cost channel of monetary policy, since expansionary monetary policy increases income, which could differentially affect demand for housing across MSAs. To isolate the cost channel, I examine the impulse responses of house prices relative to MSA-level income.

## 3.1 Data

The DiD analysis examines gentrification metrics from IPUMS and, separately, from Zillow. The IPUMS data contain MSA and sub-MSA information in 2000 (based on the the U.S. Census) and from 2005 onward (based on the American Community Survey (ACS)). IPUMS data contain information on survey respondents' educational attainment, income, and housing costs, from which MSA-level and sub-MSA-level measures of these variables can be constructed during years for which MSA-level data exist.

The timing of the MSA-level IPUMS data aligns very closely with the beginning of the MP-induced home price boom in the early 2000s depicted in Figure 2. Booms transition to and from busts approximately every five years after 2000, which motivates a DiD analysis based on changes in gentrification metrics over 5-year periods that can be classified under different MP-induced housing markets. The analysis compares changes over the two five-year periods of MP-induced housing booms (2000-2005; 2010-2015) with the five-year period of a MP-induced national housing bust (2005-2010).

The IPUMS data indicates whether the respondent lives in the central city of an MSA or the suburbs of an MSA (or whether central city status and MSA status are unknown). The within-MSA analysis will focus on differences between central cities and suburbs. There are 48 MSAs with central city status reported for each year in the sample, and these MSAs form the sample for the within-city IPUMS analysis.[9]

I supplement the analysis of IPUMS with zip-code-level Zillow Home Value Indices. The advantage of the IPUMS data is that it contains information on education and income of residents in a location. But for measuring changes in home prices and property values,

[9]IPUMS also reports respondents' Public Use Microdata Area of residence. PUMAs are constructed to contain approximately 100,000 residents and to have boundaries that do not cross state lines. PUMA boundaries change, often substantially, over time, and often extend from areas near the city center through suburbs. Therefore, I focus on central city status as the indicator of whether a respondent lives near the city center.

the Zillow data has a number of advantages. First,the Zillow index is designed to capture changing values of the underlying property (rather than changes in the quality of the housing stock).[10] Property values, rather than quality adjustments, are arguably the more relevant metric for gentrification, because as the theory below demonstrates it is the rising quality-adjusted property values that tend to displace lower-income residents.

A second benefit of the Zillow data is that the more localized zip code information permits a consistent construction of central city status across MSAs. In the IPUMS data, central cities often differ in absolute size and in size relative to the rest of the MSA. Using the Zillow data, I construct a consistent definition of downtown ares based on a threshold share of the population living closest to downtown, following Holian et al. (2012) and Couture et al. (2019). Specifically , I identify the downtown zip code for each MSA based on Google Maps searches of the City Hall for the central city. I then use the NBER Zip Code Distance Database to identify the zip codes closest to the downtown zip code that account for 10% of the MSA population.

A third and related benefit of the zip-code data is that it is possible to identify central cities for a broader range of MSAs, thus improving the power of the empirical tests. Therefore, while the IPUMS data is very useful for examining a primary gentrification metric (shares of high-education households in desirable areas), the Zillow data is preferable for examining the other gentrification metric (changes in property values).

Finally, the Zillow data exists for a range of years since the beginning of the sample, which permits a DiD analysis that excludes time periods during or after the Global Financial Crisis of 2008 (GFC). Guided by Figure 2, I focus on the 2-year expansionary period of 2003-2005 compared to the contractionary period of 2005-2007.[11]

Table 1 reports summary statistics for the primary gentrification metrics (the change in the bachelors share and home price growth) for each of the periods in our sample and across periods. The first three columns report the change in the bachelor share at different levels of aggregation: MSA (columns 1 and 2) and central cities (column 3). Column 2 reports the summary statistics for the subset of MSAs for which a central city is identified for each year in our sample. Comparing columns 1 and 2, this subsample exhibits similar changes in bachelors shares as the full sample of MSAs. The differential experience of central cities is apparent from comparing columns 2 and 3: central cities exhibit larger increases in bachelor shares (than the broader MSA) during episodes of HP-induced monetary expansions. Finally, column 4 reports zip-code level changes in the Zillow home price index.

Data on natural amenities is based on the USDA ERS natural amenities scale. The

[10] See https://www.zillow.com/research/zhvi-methodology/ for details of the underlying methodology

[11] The following criteria guide my classification of shorter pre-GFC expansionary and contractionary periods. First, the time periods should be of sufficient length to capture longer-term effects of monetary policy on housing markets. Second, the different periods should exhibit different MP-induced national housing market changes. Third, the periods should be of roughly equal length.

USDA computes a county-level summary scale of natural amenities based on factors such as average temperature, sunlight, proximity to water, and topography.[12] The USDA uses the scale to rank counties from low-amenity (1) to high-amenity (7). The scales tend to vary substantially across MSAs and less so within MSAs. Therefore, I aggregate the county-level scores to the MSA level and focus on across-MSA differences in amenities. For the DiD analysis, I classify MSAs with the highest two ranks (approximately the top fourth of MSAs) as high-amenity. I also examine how gentrificaiton metrics vary along the continuous natural amenity score.

These data are supplemented with data on MSA-level income and earnings. For the IPUMS regressions, I use total income as reported by IPUMS. For the Zillow data, which cover more MSAs than do the IPUMS data, I use aggregated measures of employee earnings from the Quarterly Census of Employment and Wages (QCEW).

## 3.2 Empirical Specification

The empirical analysis compares changes in a gentrification metric $M$ between desirable locations and less-desirable locations, during periods of MP-induced national housing market expansions and periods of MP-induced housing market contractions. The baseline specification is

$$\Delta M_{mdt} = \beta_1 Expansion_t + \beta_2 Desirable_d + \beta_3 Expansion \times Desirable + \beta_4 \Delta Inc_{mt} + \gamma_m + \epsilon_{mdt}, \tag{3}$$

where the unit of observation is location type $d$ in MSA $m$ during time period $t \in \{2000-05, 2005-10, 2010-15\}$. $Expansion_t$ indicates whether the time period is characterized as featuring an MP-induced housing market expansion. $Desirable_d$ indicates whether location $d$ is desirable (based on proximity to the city center or based on natural amenities). $\Delta Inc_{mt}$ is the growth in MSA-level income over time period $t$. $\gamma_m$ is an MSA-level fixed effect.

The IPUMS data are aggregated to the sub-MSA level $md$ for the within-MSA tests and to the MSA level $m$ for the across-MSA tests. The Zillow data is at the zip code level, so the unit of observation is zip code $z$ in location type $d$ during time period $t$. In the specifications that compare location desirability across MSAs, the indicator for desirability is absorbed by the MSA fixed effect.

[12]See https://www.ers.usda.gov/data-products/natural-amenities-scale/ for details and for a map of amenity scores across locations.

## 3.3 Results from IPUMS Data

### 3.3.1 Within-MSA Differences in Desirability

We first examine within-MSA differences in gentrification metrics by comparing locations that are presumably more desirable (central cities) to those that are presumaly less desirable (suburbs). Table 2 reports the results from specification 3 and various sample modifications. In each case the coefficient of interest, $\hat{\beta}_3$, is economically and statistically significant. According to column (1), during an expansionary MP period, the bachelors share of central cities increases by 0.027 relative to suburbs. This difference is larger than the average bachelor share change across central cities (0.023, from Table 1) and almost twice as large as the average bachelor share change across MSAs. Column (2) includes a control for MSA-level income growth. The coefficient on the interaction term of interest is attenuated only slightly.

These results are consistent with the notion that central cities are more desirable, and that the lower borrowing costs during periods of expansionary monetary policy facilitate sorting of high-income/high-education individuals into central cities. Another way to test this interpretation is to examine MSAs for which central cities are most likely to be more desirable. Cities with larger shares of high-income households tend to have more amenities, as local services and other amenities endogenously respond to local income (e.g., Couture et al. (2019)). Therefore, I use the pre-period (year 2000) bachelor share in central cities as a proxy for the relative desirability of an MSA's central city. Couture et al. (2019) define a location as being high-amenity if at least 40% of the population has a bachelors degree. I use a slightly lower threshold (35%), since the sample of MSAs with central city information and a high bachelors share is small (12 cities). Column (3) of Table 2 limits the sample to these 12 MSAs with high-amenity central cities. The coefficient on the interation term (0.075) is economically large, consistent with the notion that these central cities are highly desirable and that periods of expansionary MP strongly accelerate gentrification in these locations.

Each of the last two columns of Table 2 compares only one of the expansionary periods to the contractionary MP period. The DiD results hold qualitatively when comparing either of the expansionary periods (2000-05 or 2010-15) to the contractionary period.

Table 3 reports the results of the same analysis as 2 but with the dependent variable replaced with the growth in housing rents. As with the results for the bachelor share, housing rents increase more in central cities during periods of MP expansions. Some of the sub-samples are less statistically significant, which is likely a reflection of the small sample (and associated low power) in these specifications, as well as possible measurement error in self-reported housing rents.

### 3.3.2 Across-MSA Differences in Desirability

Gentrification can occur both because high-income residents relocate within MSAs, as well as because high-income households move from low-amenity MSAs to high-amenity MSAs, thus pricing low-income households out of high-amenity MSAs. Here I test whether changes in across-MSA gentrification are related to MP-induced national housing markets. The empirical specification is given by Equation 3, where the unit of observation is the MSA-period and the location-desirability indicator is absorbed by the MSA-level fixed effect. The DiD compares changes in gentrification metrics across MSAs of different desirability during different periods of MP-induced housing market expansions and contractions.

Table 4 reports results from DiD specifications in which changes in bachelors share (columns 1 through 4) and growth in housing rents (columns 5 through 8) are the dependent variable. High-amenity MSAs experience an increase in bachelors shares that is 0.03 higher than other MSAs during expansionary MP periods. This difference is twice as high as the average change in bachelors shares across MSAs (Table 1) and is statistically significant.

A potential concern in interpreting this coefficient is that high-amenity cities may experience higher income growth during expansionary MP periods for reasons other than the cost channel emphasized in the theory. Higher income growth would not necessarily rule out MP-related mechanisms, but it would limit the extent to which gentrification is caused by MP-induced cost reductions that disproportionately benefit high-income households (as the theory suggests). Including MSA income growth on the right-hand-side over-controls for alternative mechanisms, since even the cost channel predicts that incomes rise as high-income households move into high-amenity MSAs. Nonetheless it is informative that the DiD coefficient of interest does not change when controlling for income growth (column 2). This evidence poses a substantial hurdle for mechanisms that operate through changes in local income.

Columns (3) and (4) replace the high-amenity indicator with the continuous amenity scale (normalized by its standard deviation). A standard deviation increase in natural amenities is associated with a 0.01 increase in the bachelors share in expansionary MP periods compared to contractionary MP periods.

The results for housing rental growth are very similar. High-amenity cities experience a 13% larger housing cost increase than low-amenity cities during expansionary periods (columns 5 and 6). A standard deviation increase in natural amenities is associated with a 5% housing cost increase during expansionary periods.

## 3.4 Results from Zip-code-level Zillow Data

Here I supplement the analysis based on IPUMS data with evidence based on Zillow data. Given the advantages of the zip-code-level Zillow data discussed in Section 3.1, it serves as the benchmark for the DiD analysis. Its limitation is that it does not contain data on a key gentrification metric, the bachelors share. Therefore, there Zillow analysis and the IPUMS analysis serve as a cross-check on inferences from each other. Examining property values alone leaves open the possibility that low-income residents are equally benefiting from lower-cost credit, which might lead to higher property values but unchanged shares of high-income residents in downtown areas.

### 3.4.1 Within-MSA Differences in Desirabilty

Table 5 reports the results from the within-MSA DiD using the Zillow data. Property value growth is 8% higher in zip codes near downtown than in other zip codes during MP expansions (when controlling for MSA income -columns 2 and 3). This DiD coefficient is over half of the average 5-year property value growth across zip codes reported in 1 (0.13).

Both types of properties - all homes and single-family rentals - exhibit similar relative appreciation during MP expansions. This evidence, along with the quality-adjustments made in the construction of the Zillow indices, suggest that the DiD coefficient captures underlying property values rather than housing quality upgrades. The notion that property values are increasing more in downtown areas is consistent with the evidence from the IPUMS data that the share of low-income residents in downtown areas is falling by more during MP -induced national housing market expansions.

### 3.4.2 Across-MSA Differences in Desirability

Table 6 reports the results of the Zillow analysis in which desirability is based on natural amenity levels across MSAs. Property value growth is around 50% higher in zip codes in high-natural-amenity MSAs than in other zip codes during MP expansions (columns 1, 2, and 3). A standard deviation increase in amenities is associated with a 17% increase in the Zillow home price index during MP expansions.

## 3.5 Robustness to excluding the Global Financial Crisis

The analysis based on 5-year periods of MP-induced housing market expansion and contractions includes the GFC and its aftermath. While controlling for MSA-level income accounts for income-related channels associated with the GFC, it is possible that there are other confounding factors that differentially affect gentrification metrics across locations. Therefore, as a robustness check, I perform a similar analysis based on time periods prior to the GFC.

The following criteria guide my classification of shorter expansionary and contractionary periods. First, the time periods should be of sufficient length to capture longer-term effects of monetary policy on housing markets. Second, the different periods should exhibit different

MP-induced national housing market changes. Third, the periods should be of roughly equal length.

With these criteria in mind, I focus on the 2003-05 period of MP-induced housing market expansions and the 2005-07 period of MP-induced housing market contractions. During the expansionary period, monetary policy caused national home prices to appreciate by 12.1%. During the contractionary period, monetary policy caused national home prices to decline by 7.2%. (see Section 2 for details on this the derivation of MP-induced housing price changes).

Table 7 reports the results from the Zillow pre-GFC sample. The DiD coefficients are positive in all specifications, statistically significant in all but one specification, and approximately half the size of the DiD coefficients based on 5-year periods. The lower DiD coefficients are likely a reflection of the shorter 2-year time periods that span smaller MP-induced national home market changes. Overall, the results are consistent with the results based on 5-year housing market periods and point to MP-induced high-frequency changes in gentrification metrics.

## 3.6 Evidence from Monetary Policy Shocks

As an additional robustness check, I use an alternative identification strategy and an alternative measure of property values to examine the relationship between MP and local housing markets. Specifically, I examine the impulse responses of Case-Shiller home price indices for different MSAs to the MP shocks from Coibion et al. (2017) used in Section 2. The Case Shiller home price data include MSA-level home price indices (HPIs) for approximately 20 MSAs, each of which can be obtained from the Federal Reserve Bank of St. Louis FRED website. The HPIs begin in the late 1980s or early 1990s, depending on the MSA. I aggregate the data to the quarterly level to examine the effects of quarterly MP shocks.

To control for local housing market changes associated with changing local income, I normalize the Case Shiller index for each MSA by quarterly MSA-level income, which I obtain from the QCEW.[13]. I then obtain impulse responses for each MSA by projecting the normalized price indices on the MP shocks, as in equation 1. The series of $\hat{\beta}_1^h, h \in 0, ..., H$ constitutes the impulse response function (IRF) for that MSA.

Figure 3 plots the impulse responses to a contractionary monetary policy shock for MSAs that have the highest level of natural amenities (amenity rank between 5 and 7) and those that have the lowest level of natural amenities (amenity rank 1 through 3). High-amenity MSAs are identified by solid lines, while the impulse responses of low-amenity MSAs are depicted in dashed lines. By 16 quarters out, the IRFs for the high-amenity MSAs are almost all below the IRFs for the low-amenity MSAs, with Denver being the only high-amenity MSA with a muted response. These results are consistent with the across-MSA

[13]The home price indices and QCEW income are both in nominal terms

DiD analysis, which are based on an alternative source of identification and a different source of home price data.

# 4 Theory

The relative increase in gentrification metrics during MP expansions holds conditional on MSA income, which suggests that expansionary policy affects gentrification through its effect on housing costs rather than on income. Here I formalize a link between the cost channel of monetary policy and gentrification in a setting with two types of households (high-income and low-income) and two locations. The objective is to demonstrate conditions under which declines in borrowing costs can cause patterns in property values and bachelor shares similar to those documented in the empirical analysis.

There are two locations $l \in \{D, S\}$ into which exogenous numbers of high-income $R$ and low-income $P$ households sort. These locations can be interpreted as either downtown areas and suburbs (which considering within-MSA spatial mobility) or as high-natural-amenity MSAs and other MSAs (when considering across-MSA spatial mobility). For ease of exposition, I will refer to the locations jointly as an MSA, the desirable location $D$ as downtown, and the less desirable location $S$ as the suburbs.

The downtown location has a fixed amount of land and a pre-existing stock of old housing, while land supply is perfectly elastic in the suburbs. Land and old housing are converted into new housing by perfectly competitive developers. Low-income residents live in the old housing stock in the downtown neighborhood or in lower-quality housing in the suburbs. High-income residents live in higher-quality housing downtown or in the suburbs.[14]

Developers convert land and imported material into housing units. Expansionary monetary policy is modeled as a reduction in borrowing costs that reduces the cost of obtaining material and/or land (conditional on material and land prices).

The dominant mechanism responsible for gentrification depends on how interest-rate reductions are assumed to affect the cost of acquiring land. If land can be purchased, then an arbitrage condition implies that the rental rate of land equals the coupon on a perpetual loan used to finance the purchase of the land. The decline in interest rates leads to a fall in the coupon and hence a decline in the rental price of land. A land-market-clearing condition implies that the price of downtown land must increase. This increase in downtown land prices disproportionately affects the cost of downtown living for low-income households, as high-income households' downtown living cost also consists of materials for high-quality housing

[14]It is an assumption of the model that the representative high-income household purchases housing of higher quality than the representative low-income household. This could arise endogenously in a more complicated setup with nonhomothetic preferences over quality or with heterogeneous agents, discrete location choices, and low-income households that end up in corner solutions and cannot afford high-quality housing. To maintain simplicity, I assume differential quality consumption in a representative-agent framework.

(which benefit from the interest rate reduction). As a result, there is a shift in the relative demand for downtown housing by high-income households.

If, instead, land is rented (to developers or households) but not sold, then the downtown land rental price does not directly depend on interest rates but rather simply clears the land market. A decline in interest rates leads to a reduction in the cost of obtaining materials. This reduction in material costs disproportionately lowers the cost of downtown housing relative to suburban housing for high-income households because suburban living also consists of transportation costs that do not benefit from the interest rate reductions. As a result, high-income households' demand shifts toward downtown, pushing up the rental price of downtown land.

## 4.1 Model

A representative agent type $i \in \{R, P\}$ has utility over an imported consumption good $C$ and a composite good $\mathcal{L}$ associated with living in the MSA. The composite good consists of living in housing of quality $j \in \{A, B\}, A > B$, in the downtown location ($\mathcal{L}_{Dj}$) and the suburban location ($\mathcal{L}_{Sj}$). The benefit of living in a location is derived from housing consumption in that location as well as access to an amenity $Z$, which represents proximity to work and other amenities associated with living in the metropolitan area. I assume that accessing the amenity is costless for residents of downtown, while accessing the amenity requires a cost $\tau$ to access for suburban residents.

### 4.1.1 Households

Agent $i$'s utility is

$$U_j = \mathcal{L}_j^{\alpha} C_j^{1-\alpha}, \tag{4}$$

where

$$\mathcal{L}_i = \left( \mathcal{L}_{Dji}^{\frac{\sigma-1}{\sigma}} + \mathcal{L}_{Sji}^{\frac{\sigma-1}{\sigma}} \right)^{\frac{\sigma}{\sigma-1}} \tag{5}$$

and

$$\mathcal{L}_{lji} = \begin{cases} H_{lji}, & \text{if } Z \\ 0, & \text{otherwise} \end{cases} \tag{6}$$

Equation 6 represents complementarity between housing and metropolitan amenities in the the consumption of living in an area. It states that agents receive the utility from housing only if they also benefit from the MSA amenity. For simplicity I assume that the amenity is costless to access when housing is downtown, whereas accessing the amenity from the suburbs costs $\tau$.

Agent $i$ maximizes 4 subject to the budget constraint

$$I_i \geq p_C C_i + p_{Dj}\mathcal{L}_{Dji} + p_{Sj}\mathcal{L}_{Sji}, \tag{7}$$

where $I_i$ is agent $i$'s income, which is exogenous. $p_{lj}$ is the price of living in housing of quality $j$ in location $l$. I assume that high-income households exclusively consume high-quality housing, while low-income households consume low-quality housing.[15]

### 4.1.2 Housing production and land markets

The downtown area has a pre-existing stock of low-quality housing, which is owned by atomistic absentee landlords. This low-quality housing is rented at price $p_{DB}$. High-quality housing is produced competitively by combining the pre-existing housing (rented at $p_{DB}$) with imported materials using a Leontief production technology. A unit of high-quality housing downtown requires a unit of materials. The sales price of material is $v_M$, and the cost of the material to developers is $r \times v_M$, where $r$ is the interest rate on a perpetual bond with face value $v_M$. Therefore, the cost of high-quality downtown housing is $p^H_{DA} = p_{DB} + rv_M$.

The suburban area has a perfectly elastic supply of developable land, which has an exogenously given alternative-use rental value of $p_F$ and is also owned by an absentee landlords.[16] New housing is produced competitively by combining this land with imported material using a Leontief production technology. A unit of low-quality housing requires $\gamma < 1$ units of the imported intermediate goods, while a unit of high-quality housing requires a single unit of the imported good. Therefore, prices of suburban housing of quality $A$ and $B$ are

$$p^H_{SA} = p_F + v_M, \qquad p^H_{SB} = p_F + \gamma v_M. \tag{8}$$

To consume a unit of living $\mathcal{L}_{lj}$ in location $l$ of quality $j$, an agent must pay the cost of housing and pay for the transportation cost associated with accessing the amenity from that location. The total cost of living in housing of quality $j \in \{A,B\}$ in location $l \in \{D,S\}$ can be written as

$$p_{DB}, \quad p_{DA} = p_{DB} + rv_M, \qquad p_{SA} = p_F + rv_M + \tau, \quad p_{SB} = p_F + r\gamma p_M + \tau \tag{9}$$

### 4.1.3 Equilibrium

Equilibrium consists of housing prices $p_{lj}$ and quantities $H_{lji}$ such that households maximize utility subject to their budget constraints and subject to the prices given in equation 9 and

[15]This could arise endogenously in a more complicated setup with nonhomothetic preferences over quality or with heterogeneous agents, discrete location choices, and low-income households that end up in corner solutions and cannot afford high-quality housing.

[16]The alternative use could be farming, for example.

such that the downtown land market clears,

$$H_{DA} + H_{DB} = L_D. \tag{10}$$

It is straightforward to show that the equilibrium can be written as a single monotonic function of $p_D B$, which guarantees uniqueness of the equilibrium. The equation cannot be solved in closed-form, so comparative statics must be derived numerically.

A complete characterization of the model requires that we specify whether land can be purchased or only rented. If land is only rented, then the model is complete and no further notation is necessary. However, if land can be purchased then it is necessary to specify the relationship between the rental prices of land and the value of the land. For landlords to be indifferent between renting and selling, the rental price of the land must equal the opportunity cost of selling the land and purchasing a perpetual bond. Therefore, when selling is permitted, $p_{DB} = r \times v_{DB}$ and $p_F = r \times v_F$, where $v_{DB}$ is the sales price of low-quality downtown housing and $v_F$ is the alternative-use value of land in the suburbs.

The comparative static of interest is a decrease in the interest rate $r$. Below I examine the effects of a decline in $r$ under each assumption about the land market - that land is only rented and that land can be sold.

The effect of MP-induced borrowing cost reductions on relative demand for downtown housing is apparent in the first-order-conditions between downtown and suburban housing:

$$\frac{H_{DA}}{H_{SA}} = \left(\frac{p_F + r v_M + \tau}{p_{DB} + r v_M}\right)^{\sigma}, \qquad \frac{H_{DB}}{H_{SB}} = \left(\frac{p_F + \gamma r v_M + \tau}{p_{DB}}\right)^{\sigma}. \tag{11}$$

Consider first the partial effect of a decline in borrowing costs under the assumption that land is only rented. In this case,

$$\frac{\partial}{\partial r}\left(\frac{H_{DA}}{H_{SA}}\right) \propto p_{DB} - (p_F + \tau), \tag{12}$$

which is $< 0$ when $p_{DB} < p_F + \tau$. A decline in interest rates shifts high-income residents demand toward downtown (holding fixed other prices) when the costs of downtown living that are not directly affected by interest rates are smaller than the costs of suburban living that do not directly benefit from interest rate reductions. When then transportation cost of accessing desirable-area amenities are sufficiently large, the interest rate reduction shifts high-income residents' demand toward downtown. Meanwhile, low-income residents' demand shifts toward the suburbs, since their downtown living costs are independent of the interest rate. This combination of high-income residents' demand shifting downtown and low-income residents' demand shifting to the suburbs leads to gentrification. And when the demand shift of high-income residents is sufficiently strong ($\tau$ is sufficiently high), the net effect is an increase in downtown property values.

Next consider the case in which land can be sold. In this case, downtown land market clearing implies that the decline in $r$ must be offset by an increase in $v_{DB}$.[17] And while the decrease in $r$ in this case directly affects the entire downtown cost-of-living for high-income and low-income households, the increase in $v_{DB}$ disproportionately increases downtown living costs for low-income residents (since high-income households cost of living also consists of $v_M$). As a result, low-income households substitute suburban housing for downtown housing.

These partial-equilibrium effects operate in conjunction with other price adjustments that can in principle exacerbate or mitigate gentrification. To get a sense of the relative strength of gentrification forces, I calibrate the model under each of the assumptions regarding the downtown land market. I then simulate the effect of a 20% reduction in borrowing costs, which according to bankrate.com is the reduction in the monthly payment on a $400,000 loan when mortgage rates fall from 6.5% to 4% (consistent with the change in average rates between the 2005-10 period and the 2010-15 period).

## 4.2 Calibration

I calibrate the model to match features of IPUMS data from the 2000 U.S. Census. I normalize $I_R = 1$ and calibrate $I_P$ to match the income of households without a bachelors degree (relative to income of households with a bachelors degree). $\alpha$, the expenditure share on housing, is set to a standard value of 0.4. Land downtown $L_d$ is normalized to unity.

The remaining exogenous parameters are $\sigma$ (the elasticity of substitution between downtown and the suburbs), $p_F$ (the price of land in the suburbs), $\tau$, $v_M$, and $\gamma$. I choose values of these parameters to match the moments listed in Table 8. The first two moments are based on the share of residents with a bachelors degree. The third moment (the relative value of housing in the suburbs) is derived by obtaining the residual from a regression of the log of housing costs on observable housing characteristics (e.g., number of rooms, age of the home). I then take the ratio of the exponents of this residual for low-income residents (less than a bachelors degree) of central cities to that of low-income residents of suburbs. Housing costs are equal to rental payments (for renters) and mortgage payments (for homeowners).

The land cost share is based on the estimate in Albouy and Ehrlich (2018). Finally, the relative cost of housing in the suburbs for the poor relative to the rich is based on the relative (exponentiated) residuals from the housing cost regression between low-income residents and high-income residents of suburbs. The five parameters are exactly identified, and the model hits the target moments with precision. The calibrated parameter values are

| $\sigma$ | $p_F$ | $\tau$ | $v_M$ | $\gamma$ |
|---|---|---|---|---|
| 1.50 | 0.13 | 0.36 | 0.06 | 0.69. |

[17] Gete and Reher (2018) present evidence of an inverse relationship between the costs of credit for homeownership and local rental prices.

### 4.2.1 Quantitative evaluation of effect of a decline in housing costs

I simulate a 20% decline in $r$, both under the baseline calibration and for alternative parameter values. Table 9 reports the effect of this change under the baseline parameterization (row 1) and under alternative parameter values. Panel A shows results from the version of the model in which land is only rented (and hence interest rate declines do not directly affect land costs). In the baseline calibration of this version of the model, the housing cost decline leads to a 0.023 increase in the bachelor share of the downtown area relative to the change in the suburban bachelor share. This is slightly smaller than the within-MSA DiD coefficient estimated in column (2) (which controls for income growth) of Table 2, as well as the across-city DID coefficient of Table 4.

The baseline calibration of Panel A also predicts property value appreciation downtown of 2.7% (relative to property values $r$ in the suburbs, which are assumed to remain fixed). This is lower than the change in property values estimated in the property value regressions but is nonetheless an economically meaningful difference. One reason the property value response is small in this version of the model is that property values merely mediate the rich households' demand shift toward downtown housing. The interest rate reduction does not directly translate into lower costs of purchasing downtown land (and a corresponding increase in the present value of that land).

The effect of the interest rate reduction on gentrification metrics is relatively stable with respect to changes in parameter values. One notable exception is $\tau$. When $\tau$ is set to zero, there is only a negligible effect on relative property values. This is due to the fact that higher transportation costs are associated with a stronger demand shift toward downtown by rich households (as discussed above). When $\tau$ is zero, there is less net demand for downtown housing and downtown property values need not increase as much to clear the land market.

Panel B presents the comparative statics for the version of the model in which land can be sold (and hence $p_{DB} = rv_{DB}$ and $p_F = rv_F$). In this case, there is a large relative increase in downtown property values, reflecting the fact that $v_{DB}$ increases to clear the downtown land market, while $v_F$ remains fixed at a value determined by its alternative use. This increase in $v_{DB}$ disproportionately shifts low-income households' demand toward the suburbs. The net effect is a relative increase in downtown property rental prices and in the share of downtown housing owned by high-income households. The relative downtown land price increase is closer to the magnitudes in the empirical evidence (especially for the cross-MSA analysis). The model-simulated DiD for the bachelor share is nearly identical to both the within-MSA and the across-MSA empirical estimates. The magnitude of these effects are relatively stable with respect to parameter values. Notably, the effects are strong even when transportation costs are zero.

These simulations offer insights into the mechanisms that can account for accelerating gentrification during periods of expansionary monetary policy. A driving force behind MP-induced gentrification is that low-income residents' downtown costs-of-living falls by less than high-income residents' downtown cost-of living when interest rates fall. I have modeled this as a difference in the material input in high-income-residents' downtown housing. This modeling feature can be considered a reduced-form way of capturing other potential reasons that low-income residents of downtown might not benefit from interest rate reductions, such as restricted access to credit and/or rental prices that do not fall when interest rates fall (in conjunction with the fact that low-income households are more likely to rent).

# 5 Conclusion

Monetary policy has been highly expansionary for the greater part of the past two decades. The strong monetary response necessary to combat recessions has raised concerns that prolonged monetary stimulus may have unintended consequences.

A seemingly independent set of concerns has been the trend of gentrification over the past decades, whereby in-migration of high-income households into downtown neighborhoods has led to net outflows of low-income residents. Recent estimates imply that gentrification has led not only to higher inequality, but also to lower welfare for low-income households (Couture et al. (2019)).

In this paper I document that accelerating gentrification has been a side-effect of expansionary monetary policy. In particular, gentrification has accelerated during periods of monetary-policy-induced national housing market expansions. Desirable locations experienced larger increases in high-income-resident shares and property values than did less desirable locations in expansionary periods. This difference in differences is economically large and holds when controlling for MSA-level income growth, which suggests that borrowing costs, rather than mechanisms associated with rising incomes, are the source of gentrification acceleration.

I formalize a mechanism that can account for this evidence. When interest rate reductions pass through to the cost of living for high-income households more than for low-income households, expansionary monetary policy leads to a shift in demand for housing in desirable areas by high-income residents. This relative demand shift raises rental prices in these desirable areas and displaces low-income residents.

Differential pass-through for high-and-low-income households may arise for a number of reasons, including limited access to credit among low-income households, a higher propensity of low-income households in desirable locations to rent rather than own housing, and low-income households living in lower-quality (lower unit-cost) housing. A potentially fruitful avenue for future research is to further examine the nature of differential housing cost pass-through from monetary policy. There results of this study suggest potentially large pass-through differences across households and across locations, with low-income households in downtown areas benefiting the least from interest rate reductions.

Another potential avenue for future work is to consider additional monetary mechanisms that can account for the evidence presented here. For example, monetary policy may affect the wealth distribution in ways that increase demand for housing in desirable locations by high-income households.

# References


Agarwal, S., Chomsisengphet, S., Mahoney, N., and Stroebel, J. (2017). Do Banks Pass through Credit Expansions to Consumers Who want to Borrow?*. *The Quarterly Journal of Economics*, 133(1):129–190.

Albouy, D. and Ehrlich, G. (2018). Housing productivity and the social cost of land-use restrictions. *Journal of Urban Economics*, 107:101 – 120.

Auclert, A. (2019). Monetary policy and the redistribution channel. *American Economic Review*, 109(6):2333–67.

Baum-Snow, N. and Hartley, D. (2019). Accounting for central neighborhood change, 1980-2010. *Journal of Urban Economics*, page 103228.

Beraja, M., Fuster, A., Hurst, E., and Vavra, J. (2018). Regional Heterogeneity and the Refinancing Channel of Monetary Policy*. *The Quarterly Journal of Economics*, 134(1):109–183.

Bernanke, B. (2015). Monetary policy and inequality. Technical report, Ben Bernanke's Blog, June 1, 2015.

Bernanke, B. S. and Gertler, M. (1995). Inside the black box: the credit channel of monetary policy transmission. *Journal of Economic perspectives*, 9(4):27–48.

Bhutta, N., Laufer, S., and Ringo, D. R. (2017). Are rising home values restraining home-buying for lower-income families? Feds notes sept. 28, Board of Governors.

Chetty, R., Hendren, N., and Katz, L. F. (2016). The effects of exposure to better neighborhoods on children: New evidence from the moving to opportunity experiment. *American Economic Review*, 106(4):855–902.

Chyn, E. (2018). Moved to opportunity: The long-run effects of public housing demolition on children. *American Economic Review*, 108(10):3028–56.

Coibion, O., Gorodnichenko, Y., Kueng, L., and Silvia, J. (2017). Innocent bystanders? monetary policy and inequality. *Journal of Monetary Economics*, 88:70 – 89.

Couture, V., Gaubert, C., Handbury, J., and Hurst, E. (2019). Income growth and the distributional effects of urban spatial sorting. Working paper 26142, National Bureau of Economic Research.

Couture, V. and Handbury, J. (2019). Urban revival in america. Working paper 24084, National Bureau of Economic Research.

Favara, G. and Imbs, J. (2015). Credit supply and the price of housing. *American Economic Review*, 105(3):958–92.

Fu, C. and Gregory, J. (2019). Estimation of an equilibrium model with externalities: Post-disaster neighborhood rebuilding. *Econometrica*, 87(2):387–421.

Garriga, C., Kydland, F. E., and Šustek, R. (2019). Monk: Mortgages in a new-keynesian model. Working Paper 2019-032A, Federal Reserve Bank of Saint Louis.

Gertler, M. and Karadi, P. (2015). Monetary policy surprises, credit costs, and economic activity. *American Economic Journal: Macroeconomics*, 7(1):44–76.

Gete, P. and Reher, M. (2018). Mortgage Supply and Housing Rents. *The Review of Financial Studies*, 31(12):4884–4911.

Glaeser, E. L., Kolko, J., and Saiz, A. (2001). Consumer city. *Journal of economic geography*, 1(1):27–50.

Goodman, L. S. and Mayer, C. (2018). Homeownership and the american dream. *Journal of Economic Perspectives*, 32(1):31–58.

Guerrieri, V., Hartley, D., and Hurst, E. (2013). Endogenous gentrification and housing price dynamics. *Journal of Public Economics*, 100:45–60.

Holian, M. J., Kahn, M. E., et al. (2012). The impact of center city economic and cultural vibrancy on greenhouse gas emissions from transportation. Technical report, Mineta Transportation Institute.

Hurst, E., Keys, B. J., Seru, A., and Vavra, J. (2016). Regional redistribution through the us mortgage market. *American Economic Review*, 106(10):2982–3028.

Jiménez, G., Ongena, S., Peydró, J.-L., and Saurina, J. (2012). Credit supply and monetary policy: Identifying the bank balance-sheet channel with loan applications. *American Economic Review*, 102(5):2301–26.

Jordá, Ó. (2005). Estimation and inference of impulse responses by local projections. *American Economic Review*, 95(1):161–182.

Kuttner, K. N. (2001). Monetary policy surprises and interest rates: Evidence from the fed funds futures market. *Journal of monetary economics*, 47(3):523–544.

Lee, S. and Lin, J. (2018). Natural amenities, neighbourhood dynamics, and persistence in the spatial distribution of income. *The Review of Economic Studies*, 85(1):663–694.

Mills, E. (1967). An aggregative model of resource allocation in a metropolitan area. *American Economic Review*, 57(2):197–210.

Murphy, D. (2018). Home production, expenditure, and economic geography. *Regional Science and Urban Economics*, 70:112 – 126.

Muth, R. F. (1969). *Cities and Housing: the Spatial Pattern of Urban Residential Land Use.* University of Chicago Press.

Romer, C. D. and Romer, D. H. (2004). A new measure of monetary shocks: Derivation and implications. *American Economic Review*, 94(4):1055–1084.

Steven Ruggles, Sarah Flood, R. G. J. G. E. M. J. P. and Sobek, M. (2020). Ipums national historical geographic information system: Version 14.0. Database.

# Tables and Figures

## Tables

Table 1
Summary Statistics

| Period | | Change in Bachelor Share (IPUMS): MSA-level | MSA-level, sample with Cent City | Central Cities | Growth in Zillow HPI(zip code) |
|---|---|---|---|---|---|
| 2000-05 | Mean | 0.027 | 0.029 | 0.035 | 0.43 |
| 2005-10 | Mean | 0.007 | 0.011 | 0.011 | -0.12 |
| 2010-15 | Mean | 0.009 | 0.004 | 0.024 | 0.09 |
| Across Periods | Mean | 0.015 | 0.015 | 0.023 | 0.13 |
| | StdDev | 0.037 | 0.027 | 0.044 | 0.31 |

There are 179 MSAs in the full IPUMS sample. The subsample of 48 MSAs that have a central city identified for each year comprise the sample for columns (2) and (3).

Table 2
Within-MSA Difference in Bachelor Share Change, IPUMS Data.

| Dependent Variable: Change in bachelors share<br>Subsample: | | | High-Bachelors | First two periods | Last two periods |
|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) |
| Expansion | -0.009 | -0.007 | -0.026 | -0.025** | 0.009 |
| | (0.006) | (0.006) | (0.017) | (0.011) | (0.006) |
| Central City | -0.004 | -0.004 | -0.001 | -0.004 | -0.005 |
| | (0.005) | (0.005) | (0.011) | (0.005) | (0.005) |
| Expansion X Central City | 0.027*** | 0.028*** | 0.075** | 0.042** | 0.014* |
| | (0.009) | (0.009) | (0.025) | (0.017) | (0.008) |
| MSA income growth | | 0.021 | -0.014 | 0.020 | 0.058 |
| | | (0.013) | (0.016) | (0.016) | (0.054) |
| N | 278 | 278 | 42 | 185 | 186 |
| R2 | 0.171 | 0.191 | 0.421 | 0.286 | 0.299 |

All regressions include MSA fixed effects. The sample consists of MSAs for which a central city is identified in each period. Standard errors clustered at the MSA level are reported in parentheses. *, **, and *** indicate significance at the 0.1, 0.05, and 0.001 levels.

Table 3
Within-MSA Difference in Housing Rent Growth, IPUMS Data.

| Dependent Variable: Growth in housing rents | | | | | |
|---|---|---|---|---|---|
| Subsample: | | | High-Bachelors | First two periods | Last two periods |
| | (1) | (2) | (3) | (4) | (5) |
| Expansion | -0.094*** | -0.091*** | -0.151 | -0.074 | -0.111*** |
| | (0.034) | (0.033) | (0.094) | (0.046) | (0.040) |
| Central City | -0.053** | -0.053** | -0.036 | -0.054** | -0.058** |
| | (0.024) | (0.024) | (0.052) | (0.025) | (0.026) |
| Expansion X Central City | 0.091** | 0.092** | 0.124 | 0.072 | 0.114** |
| | (0.045) | (0.045) | (0.086) | (0.063) | (0.046) |
| MSA income growth | | 0.050 | -0.062 | 0.062 | 0.262 |
| | | (0.046) | (0.035) | (0.058) | (0.350) |
| N | 278 | 278 | 42 | 185 | 186 |
| R2 | 0.130 | 0.140 | 0.209 | 0.207 | 0.284 |

All regressions include MSA fixed effects. The sample consists of MSAs for which a central city is identified in each period. Standard errors clustered at the MSA level are reported in parentheses. *, **, and *** indicate significance at the 0.1, 0.05, and 0.001 levels.

Table 4
Across-MSA Difference in Housing Rent Growth, IPUMS Data.

| Dependent Variable: | Change in bachelors share | | | | Growth in housing rents | | | |
|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| Expansion | 0.01 | 0.01** | 0.01* | 0.01** | -0.08*** | -0.07*** | -0.08*** | -0.07*** |
| | (0.00) | (0.00) | (0.00) | (0.00) | (0.03) | (0.03) | (0.03) | (0.02) |
| Expansion X High-Amenity | 0.03** | 0.03** | | | 0.13** | 0.13** | | |
| | (0.01) | (0.01) | | | (0.06) | (0.06) | | |
| Expansion X AmenityScore | | | 0.01** | 0.01*** | | | 0.05** | 0.05** |
| | | | (0.01) | (0.00) | | | (0.03) | (0.02) |
| MSA income growth | | 0.04*** | | 0.04*** | | 0.17*** | | 0.19*** |
| | | (0.01) | | (0.01) | | (0.05) | | (0.06) |
| N | 407 | 407 | 395 | 395 | 407 | 407 | 395 | 395 |
| R2 | 0.30 | 0.41 | 0.29 | 0.41 | 0.31 | 0.39 | 0.30 | 0.39 |

The amenity score is normalized by its standard deviation. All regressions include MSA fixed effects. Standard errors clustered at the MSA level are reported in parentheses. *, **, and *** indicate significance at the 0.1, 0.05, and 0.001 levels.

Table 5
Within-MSA Difference in Property Value Growth, Zillow Data.

| Growth in Zillow Price Index: | All Homes | | Single Family Rentals |
|---|---|---|---|
| | (1) | (2) | (3) |
| Expansion | 0.37*** | 0.26*** | 0.26*** |
| | (0.03) | (0.03) | (0.03) |
| Downtown | -0.01 | -0.01 | -0.02 |
| | (0.02) | (0.02) | (0.02) |
| Expansion X Downtown | 0.07*** | 0.08*** | 0.08*** |
| | (0.02) | (0.02) | (0.02) |
| MSA income growth | | 1.26*** | 1.25*** |
| | | (0.30) | (0.29) |
| N | 28670 | 28561 | 28390 |
| R2 | 0.36 | 0.42 | 0.42 |

All regressions include MSA fixed effects. Standard errors clustered at the MSA level are reported in parentheses. *, **, and *** indicate significance at the 0.1, 0.05, and 0.001 levels.

Table 6
Across-MSA Difference in Property Value Growth, Zillow Data.

| Growth in Zillow Price Index: | All Homes | | | Single Family Rentals |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| Expansion | 0.27*** | 0.20*** | 0.23*** | 0.20*** |
| | (0.000) | (0.000) | (0.000) | (0.000) |
| Expansion X High-Amenity | 0.56*** | 0.49*** | | 0.48*** |
| | (0.000) | (0.000) | | (0.000) |
| Expansion X AmenityScore | | | 0.17*** | |
| | | | (0.000) | |
| MSA income growth | | 0.93*** | 1.01*** | 0.93*** |
| | | (0.000) | (0.001) | (0.000) |
| N | 28670 | 28561 | 28432 | 28390 |
| R2 | 0.47 | 0.50 | 0.48 | 0.50 |

The amenity score measure is normalized by its standard deviation. All regressions include MSA fixed effects. Standard errors clustered at the MSA level are reported in parentheses. *, **, and *** indicate significance at the 0.1, 0.05, and 0.001 levels.

Table 7
Analysis based on Pre-GFC Expansionary (2003-05) and Contractionary (2005-07) Periods, Zillow Data.

| DiD Specification: | Within-MSA | | Across-MSA | | | |
|---|---|---|---|---|---|---|
| Dep Var: growth in All Home or SFR HPI: | All | SFR | All | SFR | All | SFR |
| | (1) | (2) | (3) | (4) | (5) | (6) |
| Downtown | 0.016** | 0.016** | | | | |
| | (0.008) | (0.008) | | | | |
| Expansion | 0.148*** | 0.147*** | 0.112*** | 0.111*** | 0.122*** | 0.122*** |
| | (0.013) | (0.013) | (0.013) | (0.013) | (0.012) | (0.012) |
| Expansion X Downtown | 0.015* | 0.011 | | | | |
| | (0.008) | (0.010) | | | | |
| Expansion X High-Amenity | | | 0.188*** | 0.189*** | | |
| | | | (0.030) | (0.029) | | |
| Expansion X AmenityScore | | | | | 0.072*** | 0.072*** |
| | | | | | (0.007) | (0.007) |
| MSA income growth | 1.614*** | 1.615*** | 1.382*** | 1.384*** | 1.424*** | 1.425*** |
| | (0.243) | (0.244) | (0.252) | (0.247) | (0.228) | (0.225) |
| N | 18978 | 18869 | 18978 | 18869 | 18892 | 18783 |
| R2 | 0.58 | 0.58 | 0.65 | 0.65 | 0.65 | 0.65 |

All home refers to the Zillow home price index (HPI) for all homes. SFR refers to the HPI for single-family rentals. The amenity score measure is normalized by its standard deviation. All regressions include MSA fixed effects. Standard errors clustered at the MSA level are reported in parentheses. *, **, and *** indicate significance at the 0.1, 0.05, and 0.001 levels.

Table 8
Calibration Targets.

| Data Moment | Value | Source | Model Value |
|---|---|---|---|
| Share of sample population with a bachelors | 0.34 | IPUMS | $\frac{H_{SA}+H_{SB}}{H_{SA}+H_{SB}+H_{DA}+H_{DB}}$ |
| Share of Central City population with a bachelors | 0.32 | IPUMS | $\frac{H_{DA}}{H_{DA}+H_{DB}}$ |
| Value of housing in the suburbs (relative to the Central City) for residents w/o a bachelors | 1.0 | IPUMS | $\frac{p_{SB}}{p_{DB}}$ |
| Land cost share | 0.33 | Albouy and Ehrlich (2018) | $\frac{p_F}{p_F+p_M}$ |
| Cost of housing in the suburbs for the poor relative to the rich | 0.78 | IPUMS | $\frac{p_F+\gamma * v_M}{p_F+v_M}$ |

The IPUMS sample used for computing data moments is based on the cities used for the within-MSA empirical analysis (those for which Central City status is observed for each year in the empirical sample).

Table 9
Simulation Results

| | Downtown Bachelor share | MSA Bachelor share | DiD Bachelor Share | DiD Property Value Growth |
|---|---|---|---|---|
| | Panel A: Land rented only | | | |
| Baseline | 0.320 | 0.340 | 0.023 | 0.027 |
| $I_R * 1.5$ | 0.433 | 0.428 | 0.020 | 0.036 |
| $I_P * 1.5$ | 0.265 | 0.360 | 0.018 | 0.013 |
| $\sigma * 1.5$ | 0.309 | 0.320 | 0.036 | 0.012 |
| $p_F * 1.5$ | 0.322 | 0.323 | 0.023 | 0.028 |
| $L_d * 1.5$ | 0.270 | 0.249 | 0.029 | 0.031 |
| $\gamma = 1$ | 0.316 | 0.331 | 0.031 | 0.024 |
| $\tau = 0$ | 0.303 | 0.454 | 0.029 | 0.008 |
| | Panel B: Land sold or rented | | | |
| Baseline | 0.320 | 0.340 | 0.027 | 0.228 |
| $I_R * 1.5$ | 0.433 | 0.428 | 0.024 | 0.237 |
| $I_P * 1.5$ | 0.265 | 0.360 | 0.022 | 0.214 |
| $\sigma * 1.5$ | 0.299 | 0.306 | 0.060 | 0.195 |
| $p_F * 1.5$ | 0.307 | 0.327 | 0.029 | 0.228 |
| $L_d * 1.5$ | 0.321 | 0.331 | 0.026 | 0.229 |
| $\gamma = 1$ | 0.270 | 0.249 | 0.032 | 0.232 |
| $\tau = 0$ | 0.316 | 0.331 | 0.032 | 0.225 |

This table reports the simulated effect of a 20% decrease in $r$ under the assumption that land is only rented (Panel A) and the assumption that land can be sold (Panel B). The baseline calibration is reported in the first row of each panel. The other rows show the effects under alternative parameter values. The first two columns report the equilibrium bachelor shares before the interest rate decline. The third column reports the effect of the cost decline on the difference in the change in the bachelor share between downtown and suburban locations. The last column reports the difference in growth in downtown property values ($\%\Delta p_{DB}$) relative to growth in suburban property values ($\%\Delta p_F$).

## Figures

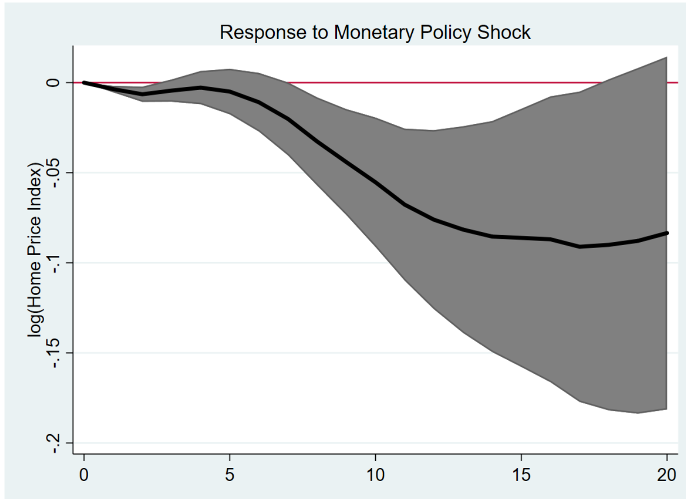


Figure 1
This figure plots the impulse response of home prices (the logarithm of the Case Shiller home price index) to a 100 basis point contractionary monetary policy shock, along with one standard deviation confidence intervals. The home price impulse response is the cumulative sum (over horizons $h$)of the differences $x_{t+h} - x_{t+h-1}$

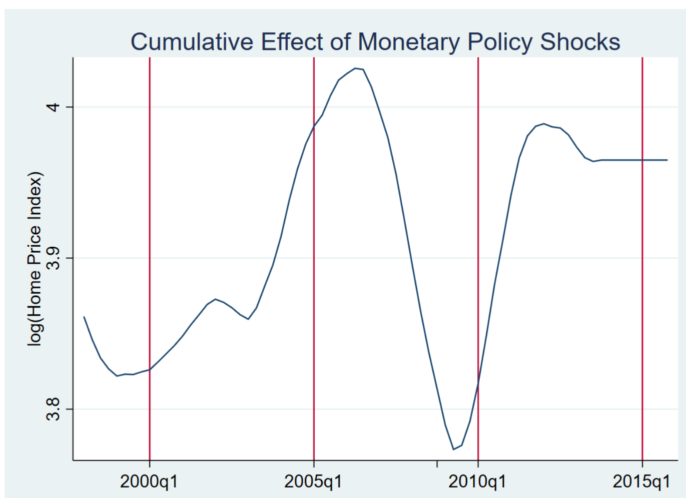


Figure 2
This figure plots the cumulative contribution of monetary policy shocks to home prices over time. Vertical lines are drawn to indicate the five-year intervals of increasing and decreasing MP-induced home price episodes. The tick on the x-axis is drawn at 2008Q4, the last quarter of the MP shock series.

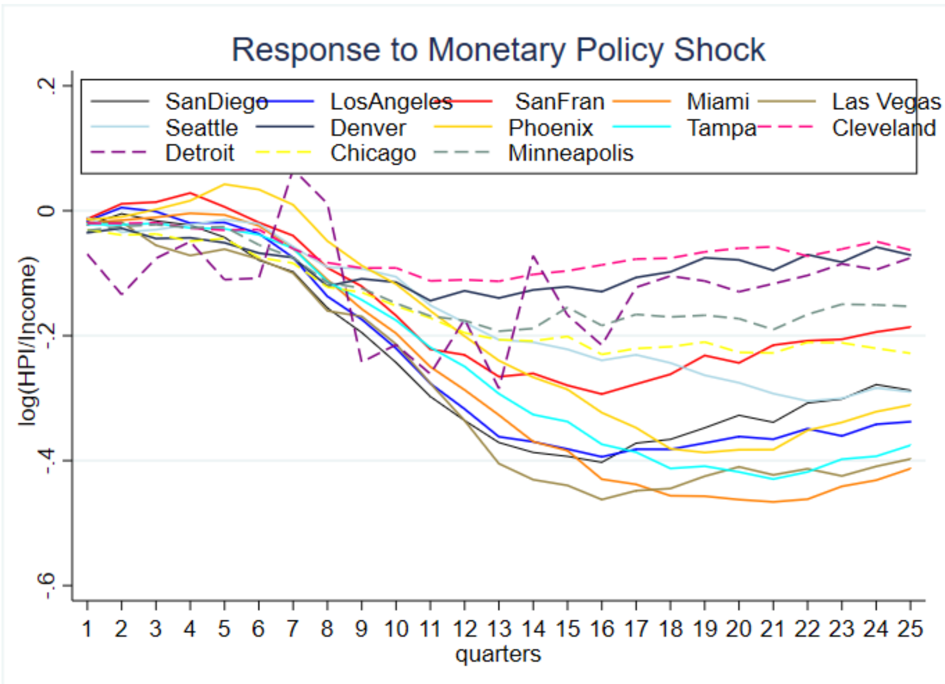


Figure 3

This figure plots the responses of MSA-level home price indices (normalized by MSA income) to a 100-basis-point contractionary monetary policy shock. Dashed lines indicate MSAs with low natural amenity scores. Solid lines indicate MSAs with high natural amenity scores.