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Not All Bank Liquidity Creation Boosts Prices — The Case of the US Housing Markets

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This paper is about investigating how different bank liquidity creation activities affect housing markets. Using data of 401 metropolitan statistical areas/metropolitan statistical area divisions (MSAs/MSADs) of the U.S. between 1990 and 2018, we show that not all bank liquidity creation activities boost the housing markets. In particular, unlike asset-side and off-balance sheet liquidity creations, funding-side liquidity creation dampens housing markets. The relationships between liquidity creation activities and housing markets are stronger in regions with inelastic house supply, but flip when banks face external liquidity shocks. We also find that housing markets dominated by large banks are more sensitive to off-balance sheet liquidity creation activities. Finally, as expected, asset-side and off-balance sheet liquidity creations boost housing markets by driving house prices away from fundamental values. Our results offer a more thorough explanation of how bank liquidity creation fuels the momentum of housing markets.

Keywords

Bank Liquidity Creation, Housing Market, House Price Fundamental, Credit Supply, Funding Resources

1. Introduction

This paper is about how housing markets react to the different bank liquidity creation activities. The real estate literature has repeatedly emphasized the role of banks on housing markets. Excess or insufficient credit supply is one of the major reasons for price fluctuations in housing markets (e.g. Kiyotaki and Moore, 1997; Keys et al., 2010; Wheaton and Nechayev, 2008; Di Maggio and Kermani, 2017). The role of banks in the housing markets is more than providing credit. In the broader sense, banks influence the real economy by funding illiquid investments with relatively liquid funding resources (Diamond and Dybvig, 1983; Diamond and Rajan, 2001; Berger and Bouwman, 2009).

Studies have noted how bank credit supply contributed to the recent boom-bust housing cycle in the late 2000s. Cox and Ludvigson (2019) find that changes in credit supply are negatively correlated with loan quality changes between 2000 and 2010, and the decreases in loan quality could both explain for house price changes and predict them. Di Maggio and Kermani (2017) allege that the preemption rule in 2004, which exempted national banks from antipredatory lending laws in the U.S., contributed to the rise and fall of credit supply, house price and unemployment rate between 2004 and 2007. Favara and Imbs (2015) also suggest that the credit expansion and reduced cost of deposits, caused by interstate branching deregulation between 1994 and 2005 in the U.S., could explain for around one-third to one-half of the rise in house price.

Recent empirical studies such as Berger and Sedunov (2017) and Davydov et al. (2018) show that liquidity creation as a more comprehensive measure of bank output could better explain for the influence of banks on the real economy. In particular, liquidity creation can be achieved via both the asset and the liability sides of the balance sheet. On the asset side, banks loan to different sectors. On the liability side, banks that manage high deposit or low capital ratios, for instance, are considered to maintain high liquidity creation (Berger and Bouwman, 2009).

As Berger and Sedunov (2017) show for the U.S. markets and Fidrmuc et al. (2015) for the Russian regions, increased liquidity creation could facilitate economic growth. However, the liquidity creation process also leaves banks with a vulnerable mismatched balance sheet (Diamond and Rajan, 2001). Therefore, only banks with lower funding liquidity risk are able to adopt more aggressive risk-taking strategies (Khan et al., 2017). Bahaj and Malherbe (2020) also theoretically prove that a higher capital requirement (that is, tighter regulations on funding-side liquidity creation) causes banks to take more risks.

This paper is the first to decompose overall bank liquidity creation into asset-side, off-balance sheet, and funding-side liquidity creations to provide a comprehensive analysis on how these different components of liquidity creation affect housing markets differently. Since a high level of liquidity creation is a consistent predictor of financial crises (Berger and Bouwman, 2017) and the procyclical liquidity creation of banks could further amplify the business cycle (Davydov et al., 2018), our study on exploring the impact of different liquidity creation activities is crucial in providing early signals of the emergence of financial crises or amplified business cycle, and therefore has important implications in regulating the real estate and banking industries. We do this for various metropolitan statistical areas/ metropolitan statistical area divisions (MSAs/MSADs), and with different bank sizes, to see how the effects differ. We adopt the theoretical framework of Campbell et al. (2009) and Plazzi et al. (2010) to control for fundamental levels of house prices relative to rents. A positive (negative) deviation from the fundamental level of the rent-to-price ratio implies underpriced (overpriced) house prices. To better capture how banks create liquidity in the housing sector, we use on-balance sheet and off-balance sheet credit supply to the housing sector to reflect the asset-side and off-balance sheet liquidity creations of banks, respectively, and decompose the total liquidity creation of banks in each MSA following Berger et al. (2016).

We find that asset-side and off-balance sheet liquidity creations lead to higher house prices relative to rents, whereas funding-side liquidity creation has the exact opposite effect. This indicates that the sources of liquidity creation based on different sides of the balance sheet of banks do not unanimously boost the housing markets. These effects are more significant in MSAs with inelastic house supply. We also emphasize that not all bank loans are equally important. Only loans created by relatively illiquid funding resources are more influential on the housing markets. The main results are robust to several different robustness checks.

We extend the study to see how the housing markets react to liquidity creation in the presence of credit shocks. Using liquidity conditions during the various recent financial crises as exogenous shocks, we find that higher pre-crisis credit supply and/or lower pre-crisis funding-side liquidity creation leads to larger downward house price adjustments during financial crises. This indicates that lenient bank credit supply and stable affluent funding sources (i.e. low funding-side liquidity creation) indeed drive house prices to further increase and away from their fundamentals during pre-crisis periods, only to result in further subsequent price drops. Finally, we find that extensive off-balance sheet credit supply is the major reason for house price increases among MSAs where large banks dominate, and the power of large banks dwarfs the influences of on-balance sheet credit supply and funding-side liquidity creation.

This paper contributes to the real estate literature by showing that not all bank liquidity creation activities positively influence housing markets, and such influences vary with bank size and housing supply elasticity. Our findings are also related to the discussions on the economic impact of bank liquidity creation by showing how real economic activities (housing markets in this case) deviate from their fundamental levels due to different liquidity creation activities. This is particularly relevant for developed countries where housing constitutes the major asset class for most households, and regulatory bodies when implementing the Basel III framework. Note that this study can be extended to test the spillover effect of bank liquidity creation in sophisticated markets, like the U.S., on other emerging markets for future research work. The empirical literature indeed supports the spillover effect of bank credit supply. For example, multinational banks tend to reduce credit supply in foreign subsidiaries when facing macroprudential regulations (Tripathy, 2020) or banking crises (Peek and Rosengren, 2000) in their home countries. Besides, monetary policies such as quantitative easing programs in the U.S. could also influence capital flow in emerging economies (Ahmed and Zlate, 2014), especially in the equity markets of emerging economies (Fratzscher et al. 2018).

The remainder of this paper is organized as follows. Section 2 describes the theoretical framework and empirical setting, while Section 3 provides the descriptions of the data and variables. Section 4 presents the empirical results and Section 5 concludes.

2. Theoretical Framework

Following Campbell et al. (2009) and Plazzi et al. (2010), we define a one-period real gross return (nominal gross return minus inflation) of the housing market i at time t+1 as

$$\Phi_{i,t+1} \equiv \left(Price_{i,t+1} + Rent_{i,t+1}\right)/Price_{i,t} \tag{1}$$

where $Price_{i,t+1}$ denotes the average real house price located in MSA i at time t+1, and $Rent_{i,t+1}$ is the average real rent.

The log real gross return is set as $\varphi_{i,t+1} \equiv \log\left(\Phi_{i,t+1}\right)$. Rearranging the right-hand side of Equation (1) and using the first-order Taylor expansion to approximate $\varphi_{i,t+1}$, we have:

$$\begin{aligned}\varphi_{i,t+1} \simeq \kappa + \rho \log\left(Price_{i,t+1}\right) + (1-\rho)\log\left(Rent_{i,t+1}\right) \\ -\log\left(Price_{i,t}\right)\end{aligned} \tag{2}$$

where $\kappa = -\log(\rho) - (1-\rho)\log(1/\rho - 1)$ and $\rho = \left(1 + \exp\left(\overline{log(Rent/Price)}\right)\right)^{-1}$. The term $\exp\left(\overline{log(Rent/Price)}\right)$ equals the average log rent-to-price ratio. Since ρ equals the average ratio of house price to the sum of rent and house price, ρ is expected to be smaller than one (Plazzi et al. (2010) suggest that the annualized value of ρ between 1994-2003 equals 0.92). Solving this equation forward by imposing the condition $\lim_{j\to\infty} \rho^j \log\left(Rent_{t+j}\right) = 0$, we obtain:

$$\log\left(Rent_{i,t}/Price_{i,t}\right) = -\frac{\kappa}{1-\rho} + E_t\left[\sum_{j=0}^{\infty}\rho^j\varphi_{i,t+1+j}\right] - E_t\left[\sum_{j=0}^{\infty}\rho^j\Delta\log\left(Rent_{i,t+1+j}\right)\right] \quad (3)$$

where, $E_t[\cdot]$denotes the expected value at time *t* (details of the derivation are shown in Appendix I).

Finally, the real gross return for MSA i at time *t*, $\varphi_{i,t}$, is defined as the sum of the real risk-free interest rate,φ_t^f , and risk premium, $\varphi_{i,t}^P$ (that is, $\varphi_{i,t}^P \equiv \varphi_{i,t} - \varphi_t^f$ and $E_t\left[\sum_{j=0}^{\infty}\rho^j\varphi_{i,t+1+j}\right] = \sum_{j=0}^{\infty}\rho^j E_t\left[\varphi_{i,t+1+j}\right] = \sum_{j=0}^{\infty}\rho^j E_t\left[\varphi_{t+1+j}^f + \varphi_{i,t+1+j}^P\right]$). Although a dynamic Gordon growth model is theoretically appealing, Gallin (2008) and Plazzi et al. (2010) suggest that the rent-to-price ratio has little predictive power on future rent growth, which implies that investors have limited abilities to predict future rent growth. We adopt a hybrid version of the Gordon constant growth model (i.e., $E_t\left[\Delta\log\left(Rent_{i,t+1+j}\right)\right] = E_t\left[\Delta\log\left(Rent_{i,t+1}\right)\right]$ for j = 0, 1, …, ∞). Besides, following Himmelberg et al. (2015) and Lai and Van Order (2017), we further simplify this model by allowing the risk premia to differ across regions but be invariant in time (i.e., $E_t\left[\varphi_{i,t+j}^P\right] = \varphi_i^P$ for j = 0, 1, …, ∞). Then,

$$\sum_{j=0}^{\infty}\rho^j\, E_t\left[\varphi_{i,t+1+j}^P\right] = \sum_{j=0}^{\infty}\rho^j\, E_t\left[\varphi_i^P\right] = \frac{\varphi_i^P}{1-\rho} \qquad \text{as } 0<\rho<1$$

As investors could lock in future interest rates by using derivatives, such as forward rate agreements and interest rate swaps, we allow the expected risk-free interest rates to vary across different maturities. Equation (3) can thus be rewritten as:

$$\log\left(Rent_{i,t}/Price_{i,t}\right) = -\frac{\kappa}{1-\rho} + E_t\left[\sum_{j=0}^{\infty}\rho^j\varphi_{t+1+j}^f\right] - E_t\left[\frac{1}{1-\rho}\Delta\log\left(Rent_{i,t+1}\right)\right] + \frac{\varphi_i^P}{1-\rho} \quad (4)$$

An earlier version of Equation (3) was first proposed by Campbell and Shiller (1998) to investigate the stock market. Black et al. (2006) subsequently apply this framework to the housing market. Since then, scholars have adopted different versions of Equations (3) and (4) to find the fundamental level of the rent-to-price ratio (e.g. Plazzi et al., 2010; Liu et al., 2017; Bourassa et al., 2019).

3. Variables, Testing Model, and Data

3.1 Variables

Log Rent-to-Price Ratio

Following Head et al. (2014), we use gross rents from the Fair Market Rents (FMR) database and repeat-sales indices from the Federal Housing Finance Agency (FHFA) to capture rents and house prices, respectively. The dependent variable, log(*Rent*/*Price*), is the log ratio between annualized gross rents from the FMR database and house price indices from the FHFA. Updated annually by the U.S. Department of Housing and Urban Development (HUD), the FMR database reports the 40th, 45th or 50th percentile of gross rent distributions for each county. Since the reported rent percentile changes over time, we follow van Nieuwerburgh and Weill (2010) to adjust the FMR data (see their Appendix D.3 for details). Together with the 2000 Census Population Report and Analysis (U.S. Census Bureau), we form a series of population-weighted gross rents for each MSA or MSAD. As the house indices are not expressed in dollars, *Rent/Price* moves proportionally with respect to the true rent-to-price ratio. [1]

Bank Liquidity Creation and Decomposition

The key independent variables in this study are the different components of liquidity creation in each MSA. Following Berger et al. (2016), we decompose bank total liquidity creation (*LC*), proposed by Berger and Bouwman (2009), into asset-side liquidity creation (*Asset LC*), funding-side liquidity creation (*Funding LC*) and off-balance sheet liquidity creation (*OffBS LC*, which are all kinds of financial derivatives, letters of credits and loan commitments, to contrast the on-balance sheet items represented by *Asset LC*) as follows. In the first step, all bank assets, funding resources (liabilities and equities) and off-balance sheet accounting entries are classified as liquid, semiliquid, and illiquid. Liquidity is created when liquid deposits or other liquid sources of funding are used to facilitate illiquid investments on the asset side. In the second step, a weight of 0.5 is assigned to illiquid assets and liquid funding resources, 0 to semiliquid assets and semiliquid funding resources, and −0.5 to liquid assets

[1] Cross-section fixed effects (i.e., MSAD FE) can absorb the differences between log(*Rent*/*Price*) and the true log ratio. To see this, let the FHFA index for market i and time t, $Price_{i,t}$, move proportionally with respect to the true house price, $r\_Price_{i,t}$, i.e., $r_{Price_{i,t}} = Price_{i,t} \times \eta_i$. We then obtain the following equation: $\log(Rent_{i,t}/r\_Price_{i,t}) = \log(Rent_{i,t}/(Price_{i,t} \times \eta_i)) = \log(Rent_{i,t}/Price_{i,t}) - \log(\eta_i)$.

Suppose the fundamental value of the true rent-to-price ratio is $\log(Rent_{i,t}/r\_Price_{i,t}) = X_{i,t}\beta$, and the fundamental value of log(*Rent*/*Price*) equals $\log(Rent_{i,t}/Price_{i,t}) = X_{i,t}\beta + \log(\eta_i)$. The cross-section fixed effects in the empirical model can capture the differences, $\log(\eta_i)$.

and illiquid funding resources following Berger and Bouwman (2009). [2] Weights for off-balance sheet entries are consistent with functionally similar on-balance sheet entries.

In brief, asset-side, funding-side and off-balance sheet liquidity creations equal the weighted sum of asset-side, funding-side and off-balance sheet accounting entries, respectively. To prevent our results from being driven by a few wealthy and populated MSAs, we normalize all three measures by population, denoted as *per capita*. We also apply log transformation to these measures to better interpret the economic meaning of the coefficients and mitigate the problem of heavily left skewness. Finally, log(*Asset LC per capita*), log(*Funding LC per capita*) and log(*OffBS LC per capita*) are used to represent the asset-side, funding-side and off-balance sheet liquidity creations in each MSA.

Since log(*Asset LC per capita*) and log(*OffBS LC per capita*) measure asset-side and off-balance sheet liquidity creations to the entire economy, we adopt an alternative decomposition to better capture the different components of liquidity creation to the housing sector. We use residential real estate loans (*OnBS RE Loan*) to reflect the on-balance sheet credit supply of the banks to the housing sector, and "unused commitments secured by residential properties" (*OffBS RE Loan*) to measure the off-balance sheet credit supply of the banks to the housing sector.[3] The total credit supply to the housing sector (*Tot RE Loan*) then equals the sum of the on-balance sheet (*OnBS RE Loan*) and off-balance sheet credit supply (*OffBS RE Loan*). Again, we normalize these factors by population and log transform them. Hence, bank liquidity creation to the housing sector is decomposed into log(*OnBS RE Loan per capita*), log(*OffBS RE Loan* per capita) and log(*Funding LC per capita*).

To estimate all previously mentioned balance sheet items for each MSA, we use the Summary of Deposits (SoD) database of the FDIC to determine the geographical distribution of bank deposits, and assume that the distribution of each balance sheet item is the same as the distribution of deposits (as in Berger

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[2] Berger and Bouwman (2009) define bank liquidity creation as turning liquid funds (e.g., demand deposits) into illiquid assets (e.g., intangible assets and commercial real estate loans). That is, Bank A increases liquidity creation by $1 if it raises $1 from liquid funding resources to invest in illiquid assets. Similarly, Bank A reduces liquidity creation by $1 if it raises $1 from illiquid funding resources to invest in liquid assets. Therefore, 0.5 is assigned to liquid funding resources and illiquid assets, –0.5 to illiquid funding resources and liquid assets, and 0 to semiliquid funding resources and assets.

[3] Since unused loan commitments are bank guarantees to provide funds and not easily sold, the function of off-balance sheet unused loan commitments is similar to that of bank loans (e.g., real estate and business loans). We therefore follow Berger and Bouwman (2009), and treat unused loan commitments as off-balance sheet "illiquid assets".

and Bouwman, 2009, Berger and Sedunov, 2017, and Dursun-de Neef, 2019)[4]. This assumption is necessary since all of the other balance sheet items do not have detailed location information, although Dursun-de Neef (2019) emphasize that making this assumption at the MSA-level can lead to measurement errors. To alleviate this concern, we further repeat our main results on state-level data since 96.11% of the banks allocated more than 95% of the total deposits to a single state between 1990 and 2018.

Panel A of Figure 1 shows the time series of the price-to-rent ratio (*Price*/*Rent*) and total liquidity creation (*LC*) over the sample period. At the aggregate level, bank total liquidity creation roughly tracks the movement of the price-to-rent ratio in the last few business cycles. As the price-to-rent ratio is the reciprocal of the rent-to-price ratio, we expect a negative relationship between bank liquidity creation and rent-to-price ratio (*Rent*/*Price*). Panel B further depicts the asset-side, funding-side and off-balance sheet liquidity creations over the sample period. As the figure shows, the recent boom and bust cycle in the mid-2000s is mostly driven by off-balance sheet liquidity creation. We also notice that the paths of the asset-side and funding-side liquidity creations have diverged, especially during the 1991 credit crunch, 2000 dot-com bubble burst, and the 2007-2009 Global Financial Crisis (GFC), in our sample period. The co-movement between liquidity creation and price-to-rent ratio (as in Panel A), and the divergence between asset-side and funding-side liquidity creation (as in Panel B) supports our motivation to explore the impact of different components of liquidity creation on the housing markets.

3.2 Empirical Testing Model

After obtaining the various liquidity creation measures, we can employ the empirical setting of Equation (4) as follows. As discussed by Campbell et al. (2009), lagged risk-free rate and rent growth can forecast further risk-free rate and rent growth, respectively. Hence, Equation (4) becomes:

$$\begin{aligned} \log\left(Rent_{i,t}/Price_{i,t}\right) = \alpha_0 + \alpha_1 r_{t-1} + \alpha_2 Term\ Spread_{t-1} \\ +\alpha_3 Avg\Delta\log\left(Rent_{i,t-1}\right) \\ +\sum_{j=1}^{n} \beta_j LiquidityCreation_{i,j,t-1} \\ +\sum_{k=1}^{3} \beta_j Macro_{i,k,t-1} + \mu_i + \varepsilon_{i,t} \end{aligned} \tag{5}$$

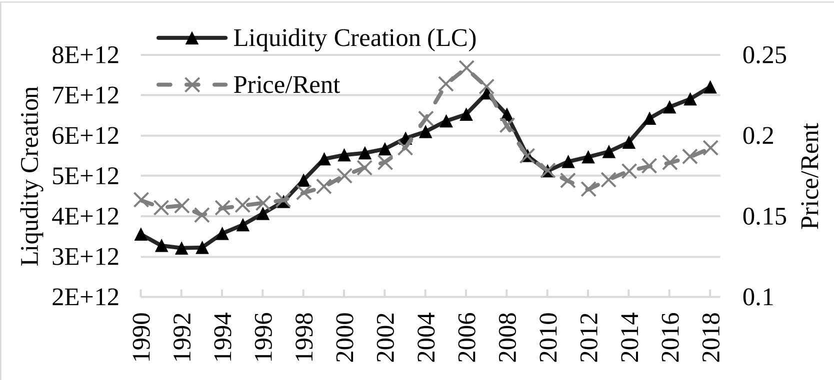
where r_{t-1} is the risk-free real interest rate at time t-1, proxied by the difference between the 10-year Treasury constant maturity rate and inflation. *Term*

[4] Home Mortgage Disclosure Act (HMDA) data is a possible source as most banks are obligated to disclosure the basic characteristics of mortgages originated or purchased in the previous calendar year following the act. However, HMDA data cannot track whether mortgage loans are securitized or held to maturity, and hence cannot provide geographic details of mortgage loans held by each bank.

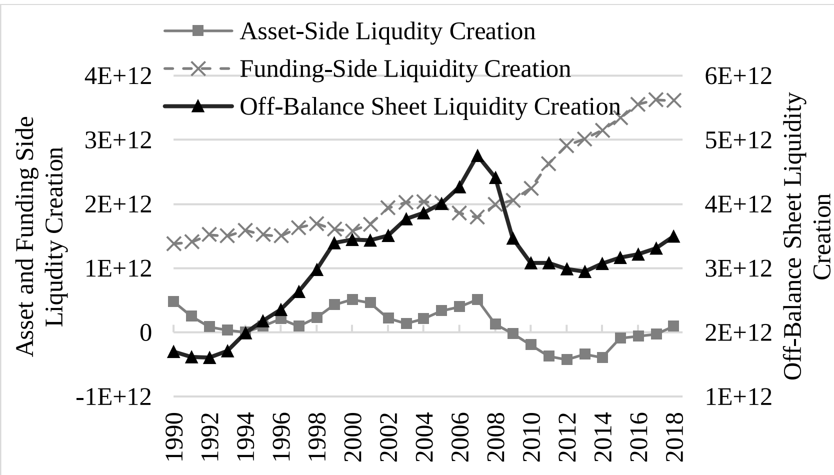
Spread$_{t\text{-}1}$ denotes the interest rate spread between 3-month and 10-year Treasury constant maturity rates at time *t*-1. It is used to capture the differences between $E_t[\varphi_t^f]$ and $E_t[\varphi_{t+j}^f]$. $Avg\Delta\log(Rent_{i,t-1})$ equals the average real rent growth of MSA *i* over the prior four years (*t*-1 to *t*-4), to capture the expectations of

Figure 1 Liquidity Creation and Housing Market

Panel A: Liquidity Creation and Price to Rent Ratio



Panel B: Asset Liquidity Creation vs. Funding Liquidity Creation



Notes: Panel A plots the total liquidity creation (USD) and price to rent ratio over the period of 1990-2018. Panel B depicts the asset-side, funding-side and off-balance sheet liquidity creations separately (as in Berger et al., 2016). Price/rent denotes the ratio between national level FHFA housing price index and population-weighted gross rent. All variables are calculated in 2018 real dollars, with the use of national CPI excluding shelter.

Sources: Federal Housing Finance Agency (FHFA) and U.S. Department of Housing and Urban Development (HUD).

investors on rent growth over the long-term. $Liquidity\ Creation_{i,j,t\text{-}1}$ is the j-th liquidity creation related measure for MSA i at time t-1 discussed in the previous section. All liquidity creation measures are lagged one period to mitigate the issue of endogeneity. Following Campbell et al. (2009), we include lagged local income growth, and employment growth and population growth as macroeconomic factors ($Macro_{i,1}$ to $Macro_{i,3}$). Finally, we employ fixed effects, μ_i, to control the influence of risk premia, φ_i^P (as in Lai and Van Order, 2017). We report the heteroscedasticity, autocorrelation and cluster-robust standard errors of all of the regressions.

3.3 Data

Panel A of Table 1 reports the definitions for the variables used in our study and their sources, and Panel B shows the summary statistics for the main variables. Using balance sheet information, house price indices and gross rents which are described in Section 3.1, and control variables from different sources, we construct an unbalanced panel that consists of data for the 401 MSAs/MSADs.[5] The sample period is 1990-2018, which includes three major crises: the 1990-1991 credit crunch, 2000-2001 do-com bubble crash and 2007-2009 GFC. We choose to start the sample with 1990 because banks are required to disclose detailed information of their off-balance sheet credit supply to the real estate sector starting in 1990. We include all traditional deposit-taking and loan-making banks in this study, and include a bank in the sample if it (i) holds nonzero portfolios of outstanding loans, (ii) has deposits, and (iii) has an equity to gross total asset (GTA) ratio of at least 1%. All financial variables are calculated in 2018 real dollars with the use of national consumer price index (CPI) excluding shelter. The panel unit root test results verify that all the variables are stationary. As distribution of deposits and regional-level rent data are reported annually, our analyses are also done at an annual frequency.

Panel C presents the correlation matrix for the major variables. Our key independent variables, log(*OnBS RE Loan per capita*) and log(*OffBS RE Loan per capita*), are highly correlated, with a correlation coefficient of 0.724. To mitigate the concern of multicollinearity, we regress log(*Rent*/*Price*) on log(*OnBS RE Loan per capita*), log(*OffBS RE Loan per capita*), log(*Funding LC per capita*) and all of the control variables. The maximum variance inflation factor of 3.04 is much smaller than the threshold of 10, and hence multicollinearity is not a concern in our results.

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[5] There are 384 MSAs in the US, excluding those in Puerto Rico. The 11 largest and most populated MSAs are further divided into 31 MSADs, following the definitions of the FHFA which reports the quarterly house price index for all 404 MSAs/MSADs. We include 401 MSAs/MSADs in our analysis because we do not have bank liquidity creation information for 3 of the MSAs (i.e. Harrisonburg, VA, Kahului-Wailuku-Lahaina, HI and Staunton, VA).

Table 1 Variable Definitions, Sources and Summary Statistics

This table provides the definitions, sources, and summary statistics of the dependent and key independent variables. The sample period starts in 1990, since banks have been obligated to report off-balance sheet real estate loans since 1990. All financial variables are converted to 2018 dollars, with the use of CPI excluding shelter. As the distribution of deposits and regional-level rent data are reported at an annual frequency, we conduct our analysis with this frequency and use December call reports to calculate the bank level variables.

Panel A: Variable Definitions and Sources

Variable	Definition	Source(s)
Dependent Variable:		
log(*Rent/Price*)	Log ratio between annualized gross rent from Fair Market Rents database and repeat-sales house price indices from FHFA	FHFA and HUD
Alternative Key Independent Variable:		
log(*LC per capita*)	Log ratio between total liquidity creation of all banks in the MSA (in 2018 dollars) and the population.	Call reports and BEA
log(*Asset LC per capita*)	Log ratio between assets-side liquidity creation of all banks in the MSA (in 2018 dollars) and population.	Call reports and BEA
log(*OffBS LC per capita*)	Log ratio between off-balance sheet liquidity creation of all banks in the MSA (in 2018 dollars) and population.	Call reports and BEA
log(*Funding LC per capita*)	Log ratio between funding-side liquidity creation of all banks in the MSA (in 2018 dollars), and population.	Call reports and BEA
log(*OnBS RE Loan per capita*)	Log ratio between on-balance sheet residential real estate loans held by all banks in the MSA (in 2018 dollars) and population.	Call reports and BEA
log(*OffBS RE Loan per capita*)	Log ratio between unused commitments secured by residential properties held by all banks in the MSA (in 2018 dollars) and population.	Call reports and BEA
log(*Tot RE Loan per capita*)	Log ratio between the sum of *OnBS RE Loan* and *Off RE Loan* and population.	Call reports and BEA

(*Continued…*)

(Table 1 Continued)

Variable	Definition	Source(s)
Control Variable		
r	Constant maturity real rate of 10-year Treasury bonds	Federal Reserve Board
Term Spread	Interest rate spread between 3-month and 10-year Treasury constant maturity rates	Federal Reserve Board, and Authors' calculation
*Avg*Δlog(*Rent*)	Average growth rate of real rents in prior four years	Authors' calculation
Δlog(*Income per capita*)	Difference between log real per-capita income and lagged log real per-capita income in the MSA.	BEA
Δlog(*Population*)	Difference between log population and lagged log population in the MSA.	BEA
Δlog(*Employment*)	Difference between log employment and lagged log employment in the MSA.	BEA
Other:		
log(*OnBS RE Loan/Funding LC*)	Log ratio between on-balance sheet residential real estate loans and funding-side liquidity creation of all banks in the MSA	Call reports and Authors' calculation
log(*OffBS RE Loan/Funding LC*)	Log ratio between unused commitments secured by residential properties and funding-side liquidity creation of all banks in the MSA	Call reports and Authors' calculation
log(Tot *RE Loan/Funding LC*)	Log ratio between total credit supply to the housing sector and funding-side liquidity creation of all banks in the MSA	Call reports and Authors' calculation
Supply Elasticity	Index that measures supply elasticity of the housing market in each MSA.	Saiz (2010)
Rice-Strahan index	Index that reflects geographical restrictions on bank interstate expansion. The index considers four interstate branching barriers and equals zero for states with no interstate branching restrictions.	Rice and Strahan (2010)

Panel B: Summary Statistics

	Count	Mean	Std. Dev.	Min	Median	Max
Dependent Variable						
log(*Rent*/*Price*)	11493	4.069	0.222	3.277	4.058	5.421
Key Independent Variable						
log(*Funding LC per capita*)	11466	8.598	0.486	5.4700	8.569	13.492
log(*OnBS RE Loan per capita*)	11493	8.391	0.605	6.037	8.396	13.107
log(*OffBS RE Loan per capita*)	11064	6.424	1.166	-7.491	6.567	11.260
log(*Tot RE Loan per capita*)	11493	8.546	0.623	6.094	8.555	13.254
Alternative Independent Variable						
log(*LC per capita*)	11493	9.281	0.647	5.901	9.246	14.966
log(*Asset LC per capita*)	9335	7.323	0.996	-0.602	7.500	11.568
log(*OffBS LC per capita*)	11493	8.218	0.817	5.140	8.144	14.891
Control Variable						
R	11493	0.023	0.016	-0.012	0.026	0.046
Term Spread	11493	0.019	0.010	0.000	0.017	0.036
*Avg*Δlog(*Rent*)	11493	0.003	0.023	-0.322	0.001	0.291
Δlog(*Income per capita*)	11493	0.014	0.027	-0.376	0.014	0.376
Δlog(*Population*)	11493	0.010	0.012	-0.287	0.009	0.096
Δlog(*Employment*)	11493	0.013	0.021	-0.156	0.014	0.196
Other						
log(*Tot RE Loan*/*Funding LC*)	11111	-0.053	0.489	-2.030	-0.049	4.905
log(*OnBS RE Loan*/*Funding LC*)	11466	-0.208	0.467	-2.032	-0.212	4.186
log(*OffBS RE Loan*/*Funding LC*)	11064	-2.176	1.083	-15.856	-2.015	4.237

Panel C: Correlation Matrix

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
(1) log(*Rent/Price*)	1													
(2) log(*LC per capita*)	0.086	1												
(3) log(*Asset LC per capita*)	-0.138	0.495	1											
(4) log(*OffBS LC per capita*)	0.139	0.940	0.372	1										
(5) log(*Funding LC per capita*)	0.126	0.780	0.235	0.654	1									
(6) log(*OnBS RE Loan per capita*)	-0.016	0.622	0.328	0.536	0.637	1								
(7) log(*OffBS RE Loan per capita*)	-0.040	0.546	0.390	0.544	0.444	0.724	1							
(8) log(*Tot RE Loan per capita*)	-0.026	0.637	0.352	0.562	0.627	0.992	0.796	1						
(9) *r*	0.182	-0.008	-0.112	0.066	-0.046	-0.176	-0.303	-0.207	1					
(10) *Term Spread*	0.107	-0.073	-0.124	-0.111	0.037	-0.003	-0.004	-0.008	-0.059	1				
(11) *Avg*Δlog(*Rent*)	-0.048	0.070	0.102	0.018	0.095	0.131	0.167	0.140	-0.091	-0.053	1			
(12) Δlog(*Income per capita*)	0.018	0.039	-0.043	0.040	0.071	-0.005	-0.038	-0.013	0.121	-0.222	0.041	1		
(13) Δlog(*Population*)	0.061	0.059	0.000	0.102	-0.001	-0.170	-0.112	-0.162	0.153	-0.036	-0.040	-0.047	1	
(14) Δlog(*Employment*)	0.055	0.048	-0.076	0.082	0.058	-0.122	-0.136	-0.127	0.029	-0.322	-0.097	0.421	0.488	1

Note: The key independent variables, log(*OnBS RE Loan per capita*) and log(*OffBS RE Loan per capita*), are highly correlated, with a correlation coefficient of 0.724. Since the maximum variance inflation factor (VIF) of 3.04 is much smaller than the threshold of 10, multicollinearity is not a concern in the main results. FHFA denotes Federal Housing Finance Agency, HUD denotes U.S. Department of Housing and Urban Development, and BEA denotes U.S. Bureau of Economic Analysis.

4. Empirical Results and Analysis
4.1 Baseline Estimation

Table 2 reports the baseline regression results of Equation (5). In Panel A, we test the aggregate influence of bank liquidity creation on the housing markets in Model (1), and the influence of each of the three major components of liquidity creation in Model (2). The negative coefficient of log per capita liquidity creation, log(*LC per capita*), in Model (1) implies that increased bank liquidity creation indeed boosts house prices relative to rent (decreases the rent-to-price ratio). Model (2) shows that increased asset-side, log(*Asset LC per capita*), and/or off-balance sheet liquidity creation, log(*OffBS LC per capita*), can boost house prices relative to rent, while increased funding-side liquidity creation, log(*Funding LC per capita*), has an opposite effect.[6] Hence, when liquidity is created through asset-side activities, more credit supply is directed to the real estate sector and boosts up housing prices. On the other hand, liquidity created due to funding-side activities do not facilitate the housing markets. This provides us with a preliminary indication that asset-side and funding-side liquidity creations have opposite effects on the housing markets.

Since banks can choose among the different industries, a high level of asset-side liquidity creation to the entire economy does not necessarily mean a large credit supply to the housing sector. We therefore regress the rent-to-price ratio on total bank credit supply to the housing sector, log(*Tot RE Loan per capita*), in Model (3), and further split the total bank credit supply into on-balance sheet and off-balance sheet credit supply, i.e. log(*OnBS RE Loan per capita*) and log(*OffBS RE Loan per capita*), respectively, in Model (4).[7] The results of Models (3) and (4) show that both on- and off- balance sheet credit supply can boost house prices relative to rent. To test the economic significance of the results, we multiply the coefficients of log(*OnBS RE Loan per capita*) and log(*OffBS RE Loan per capita*) by their corresponding standard deviations (0.605 and 1.166, respectively, from Table 1). A one standard deviation increase in log(*OnBS RE Loan per capita*) and log(*OffBS RE Loan per capita*) reduces the rent-to-price ratio by 4.72% (i.e. $0.605\times|-0.078|$) and 5.13% (i.e. $1.166\times|-0.044|$), respectively. So, even though the coefficients of log(*OnBS RE Loan per capita*) and log(*OffBS RE Loan per capita*) are relatively small, the economic impact of on- and off-balance sheet residential real estate loans is substantial.

[6] Some of the MSAs have negative *Asset LC per capita* after the GFC, and log(*Asset LC per capita*) is missing. So, Model (2) has significantly fewer observations than the other models.

[7] log(*Tot RE Loan per capita*) = log(*OnBS RE Loan per capita* + *OffBS RE Loan per capita*)

Table 2 Liquidity Creation and Rent-to-Price Ratio

This table reports the baseline regression results of how liquidity creation influences the rent to price ratio. The dependent variable is log rent-to-price ratio, log (*Rent*/*Price*). The independent variables are described in Panel A of Table 1. Standard errors, which are clustered at the MSA level, are reported in parentheses. *, **, *** denote significance at the 10%, 5% and 1% levels, respectively.

Dependent Variable: log(*Rent*/*Price*)	(1)	(2)	(3)	(4)	(5)	(6)
log(*LC per capita*)$_{t\text{-}1}$	-0.099***				-0.037***	
	(0.010)				(0.012)	
log(*Asset LC per capita*)$_{t\text{-}1}$		-0.013***				0.003
		(0.003)				(0.003)
log(*OffBS LC per capita*)$_{t\text{-}1}$		-0.090***				-0.033***
		(0.012)				(0.011)
log(*Funding LC per capita*)$_{t\text{-}1}$		0.045***	0.073***	0.052***	0.068***	0.067***
		(0.015)	(0.010)	(0.010)	(0.011)	(0.013)
log(*Tot RE Loan per capita*)$_{t\text{-}1}$			-0.153***			
			(0.009)			
log(*OnBS RE Loan per capita*)$_{t\text{-}1}$				-0.078***	-0.073***	-0.037**
				(0.013)	(0.013)	(0.018)
log(*OffBS RE Loan per capita*)$_{t\text{-}1}$				-0.044***	-0.039***	-0.092***
				(0.008)	(0.008)	(0.017)
r_{t-1}	1.720***	1.689***	0.584***	0.329**	0.376**	-0.096
	(0.153)	(0.170)	(0.148)	(0.153)	(0.151)	(0.204)

(*Continued…*)

(Table 2 Continued)

Dependent Variable: log(*Rent*/*Price*)	(1)	(2)	(3)	(4)	(5)	(6)
Term Spread$_{t-1}$	1.342***	0.814***	1.571***	1.613***	1.389***	1.149***
	(0.100)	(0.147)	(0.118)	(0.115)	(0.125)	(0.152)
*Avg*Δlog(*Rent*)$_{t-1}$	-0.323***	-0.454***	-0.211**	-0.111	-0.084	-0.022
	(0.101)	(0.125)	(0.103)	(0.103)	(0.103)	(0.123)
Δlog(*Income per capita*)$_{t-1}$	-0.460***	-0.441***	-0.420***	-0.344***	-0.339***	-0.249***
	(0.063)	(0.069)	(0.063)	(0.059)	(0.058)	(0.060)
Δlog(*Population*)$_{t-1}$	-2.656***	-2.485***	-2.888***	-2.823***	-2.749***	-2.957***
	(0.436)	(0.520)	(0.470)	(0.473)	(0.470)	(0.599)
Δlog(*Employment*)$_{t-1}$	0.186*	-0.031	-0.295***	-0.385***	-0.410***	-0.637***
	(0.106)	(0.115)	(0.104)	(0.106)	(0.103)	(0.121)
Constant	4.950***	4.482***	4.739***	4.553***	4.685***	4.671***
	(0.091)	(0.106)	(0.097)	(0.086)	(0.093)	(0.100)
Observations	11,493	9,183	11,111	11,064	11,063	8,953
Adj. R-squared	0.137	0.129	0.203	0.209	0.213	0.228
MSA FE	YES	YES	YES	YES	YES	YES

It is also worth noting that the coefficients of log(*OnBS RE Loan per capita*) and log(*OffBS RE Loan per capita*) are not directly comparable. As shown in Table 1, the average per capita on-balance sheet credit supply equals $e^{8.3908}$ = \$4406.34, whereas the average per capita off-balance sheet credit equals $e^{6.4238}$ = \$616.34. This suggests that the same change in monetary term would lead to roughly a seven times (i.e. 4406.34/616.34 = 7.15) larger change in log(*OffBS RE Loan per capita*) than in log(*OnBS RE Loan per capita*). Therefore, for an average MSA, the impact of an increase in the off-balance sheet credit supply is around four times (0.044×7.15/0.078) larger than that in the on-balance sheet credit supply. In other words, house prices are four times more sensitive to funds from off-balance sheet credits in the form of, for example, financial derivatives, letters of credits and loan commitments, than on-balance sheet credits.

Nonetheless, the coefficients of lagged log(*Funding LC per capita*) across all specifications are always positive and statistically significant. Based on Model (4), a one standard deviation increase in log(*Funding LC per capita*) raises the rent-to-price ratio by 2.53% (i.e. 0.486×0.052). One possible explanation is that banks that rely on liquid funding resources are also more likely to behave conservatively when investing in relatively illiquid collateralized loans (Niinimaki, 2009) due to a higher probability of experiencing a liquidity shock (Bhattacharya and Thakor, 1993). In other words, banks that have a higher short term liquidity risk tend to apply tighter credit rationing standards unless loaning to undervalued housing markets (a high rent-to-price ratio). Besides, a high level of funding-side liquidity creation also indicates that funding providers favor liquid assets over illiquid ones, and therefore require higher risk premia when loaning to relatively illiquid housing projects. This also dampens the housing market (as represented by the larger rent-to-price ratio).

To ease the concern that the on- and off- balance sheet credit supply of banks to the housing market are correlated with other liquidity creation activities, we further add total liquidity creation to Model (5) and asset-side and off-balance sheet liquidity creations to Model (6). The signs and magnitude of the key independent variables from Model (5) are in line with our baseline results in Model (4), which indicates that other bank liquidity creation do not affect their strategies of supplying credit to the housing market.[8] The magnitude of the coefficients of log(*LC per capita*) and log(*OffBS LC per capita*) is reduced by 62.63% (|−0.037|/|−0.099|−1) and 63.33% (|−0.033|/|−0.090|−1), respectively, and the coefficient of log(*Asset LC per capita*) becomes insignificant. These suggest that some of the off-balance sheet activities affect the housing markets, in addition to the on- and off-balance sheet credit supply.

[8] Some MSAs have negative *Asset LC per capita* after the GFC, and thus undefined log(*Asset LC per capita*), so Models (2) and (6) could be subject to the problem of selection bias. We therefore use Models (2) and (6) as references only.

The signs and significance of the control variables are as expected. The positive significant coefficients of real interest rate (*r*) and term spread (*Term Spread*) and the negative significant coefficients of average rent growth (*Avg*Δlog(*Rent*)) validate the theoretical framework proposed by Campbell et al. (2009) and Plazzi et al. (2010). In line with Campbell et al. (2009) and Jud and Winkler (2002), lagged income, population and employment growths could also help to predict the rent-to-price ratio.

Table 3 State-Level Regressions

In this table, we repeat Models (2) to (4) of Table 2 on state-level data and present the fixed effect model regression results. The sample period is 1990-2018. Standard errors, which are clustered at the state level, are reported in parentheses. *, **, *** denote significance at the 10%, 5% and 1% levels, respectively.

Dependent Variable: log(*Rent*/*Price*)	(1)	(2)	(3)
log(*Asset LC per capita*)$_{t-1}$	-0.014		
	(0.010)		
log(*OffBS LC per capita*)$_{t-1}$	-0.067***		
	(0.018)		
log(*Funding LC per capita*)$_{t-1}$	0.031	0.089***	0.059**
	(0.025)	(0.028)	(0.024)
log(*Tot RE Loan per capita*)$_{t-1}$		-0.131***	
		(0.024)	
log(*OnBS RE Loan per capita*)$_{t-1}$			-0.019
			(0.027)
log(*OffBS RE Loan per capita*)$_{t-1}$			-0.082***
			(0.018)
r_{t-1}	2.434***	1.609***	0.876**
	(0.511)	(0.394)	(0.386)
Term Spread$_{t-1}$	0.569*	1.098***	0.868***
	(0.330)	(0.279)	(0.264)
*Avg*Δlog(*Rent*)$_{t-1}$	-1.801***	-1.806***	-1.505***
	(0.314)	(0.314)	(0.320)
Δlog(*Income per capita*)$_{t-1}$	-0.405**	-0.273	-0.079
	(0.200)	(0.170)	(0.162)
Δlog(*Population*)$_{t-1}$	-3.506*	-5.234***	-4.570***
	(2.041)	(1.467)	(1.496)
Δlog(*Employment*)$_{t-1}$	0.306	-0.576*	-0.997***
	(0.403)	(0.290)	(0.306)
Constant	3.881***	3.882***	3.721***
	(0.233)	(0.181)	(0.173)
Observations	1,102	1,421	1,421
Adj. R-squared	0.229	0.369	0.408
State FE	YES	YES	YES

Since most banks operate in more than one MSA, the popular assumption that distribution of bank deposits matches the distribution of other balance sheet items (e.g. Berger and Bouwman, 2009, Berger and Sedunov, 2017, and Dursun-de Neef, 2019) may lead to measurement errors. To mitigate this concern, we repeat Models (2) to (4) of Table 2 on state-level data, and report the results in Table 3. The regression results are mostly consistent with our main results. The bank credit supply, especially off-balance sheet credit supply, tends to inflate house prices relative to rent (decreases the rent-to-price ratio), while bank funding-side liquidity creation reduces house prices relative to rent (increases the rent-to-price ratio).

Moreover, we also conduct several robustness checks. On the asset-side, an increase in bank credit supply could be either due to the increased preference for residential real estate loans over other assets or an expansion in size. We therefore add the ratio of total residential real estate loans and total assets to control the effect. We find a negative relationship between this newly added variable and rent-to-price ratio. This also supports our main results that credit supply is negatively correlated with the rent-to-price ratio. On the funding-side, deposits and equities are the two main funding resources for banks, and on average, comprised 83.29% and 11.93% of the total funding resources at the end of 2018, respectively. Following Berger and Bouwman (2009), we consider demand deposits as liquid funding resources and term deposits as semiliquid funding resources, and further explore the influence of different funding resources by including the ratio between total deposits and total assets, and the ratio between demandable deposits and total deposits. The positive coefficients of those two variables also provide supportive evidence for the positive linkage between funding-side liquidity creation and rent-to-price ratio. Details of the regression results are provided in Appendix II.

4.2 Impact of External Liquidity Shocks

Even though all of the independent variables are lagged one period to avoid the problem of reverse causality, we still cannot assume that the measures of bank liquidity creation are completely exogenous. For example, banks may expand credit supply when they anticipate a housing boom, and/or shrink their business when they foresee a declining trend in house price movement. In this section, we mitigate this by using financial crises as the external liquidity shock as in Cornett et al. (2011) and Dursun-de Neef (2019). If a large supply of credit causes the rent-to-price ratio to deviate downward from its fundamental level (an excessively low $\log(Rent/Price)$) during normal periods, we should observe a significant increase in the rent-to-price ratio (a positive $\Delta\log(Rent/Price)$) when banks face unexpected external liquidity shocks during a crisis. In other words, the sign of the coefficients of the key independent variables should be the opposite of our main results.

To test this hypothesis, we regress log changes in the rent-to-price ratio on the level of on-balance sheet credit supply, off-balance sheet credit supply and funding-side liquidity creations during the pre-crisis peak periods. The regression results are reported in Table 4. Our sample period includes the three aforementioned major crises: the 1990-1991 credit crunch, 2000-2001 dot-com bubble burst and 2007-2009 GFC. According to the National Bureau of Economic Research (NBER) Business Cycle Dating Committee, the three business cycles peaked in 1990, 2000 and 2007, and troughed in 1991, 2001 and 2009, respectively. Our empirical results in general support the hypothesis by showing that when an MSA housing market has a large pre-crisis supply of credit and/or low pre-crisis funding-side liquidity creation, this housing market will experience a larger house price decline (more positive Δlog(*Rent*/*Price*)) during the crisis.

Table 4 Financial Crises as External Liquidity Shocks

This table shows the ordinary least squares regression results. The dependent variable is log change in rent-to-price ratio during financial crises, Δlog(*Rent*/*Price*), which equals the difference between its level at the trough of business cycle and its level at the (pre-crisis) peak. Peak and trough are determined based on NBER Business Cycle Dating Committee. log(*OnBS RE Loan per capita*)$_{Pre}$ and log(*OffBS RE Loan per capita*)$_{Pre}$ measure pre-crisis level of on-balance sheet and off-balance sheet residential real estate loan supply, respectively. log(*Funding LC per capita*)$_{Pre}$ reflects pre-crisis level of funding-side liquidity creation. Δlog(*Income per capita*)$_{Pre}$, Δlog(*Population*)$_{Pre}$ and Δlog(*Employment*)$_{Pre}$ denote pre-crisis level of per capita income growth, and population and employment growth, respectively. Heteroscedasticity-robust standard errors are reported in parentheses. *, **, *** denote significance at the 10%, 5% and 1% levels, respectively.

Dependent Variable: Δlog(*Rent*/*Price*)	(1)	(2)	(3)	(4)
log(*Tot RE Loan per capita*)$_{Pre}$	0.069***	0.069***		
	(0.005)	(0.006)		
log(*OnBS RE Loan per capita*)$_{Pre}$			0.019**	0.018**
			(0.0090)	(0.008)
log(*OffBS RE Loan per capita*)$_{Pre}$			0.023***	0.024***
			(0.004)	(0.005)
log(*Funding LC per capita*)$_{Pre}$	-0.042***	-0.041***	-0.024***	-0.022***
	(0.009)	(0.009)	(0.008)	(0.008)
Δlog(*Income per capita*)$_{Pre}$		-0.240		-0.324*
		(0.195)		(0.196)
Δlog(*Population*)$_{Pre}$		0.677*		0.354
		(0.373)		(0.380)
Δlog(*Employment*)$_{Pre}$		-0.638**		-0.578**
		(0.286)		(0.293)
Constant	-0.180**	-0.182**	-0.059	-0.057
	(0.077)	(0.078)	(0.083)	(0.083)
Observations	1148	1148	1148	1148
Adj. R-Squared	0.113	0.123	0.116	0.126

4.3 Regions with High and Low House Supply Elasticities.

We propose that an increase in housing loans, especially when they are financed through illiquid (stable) funding resources, can reduce financial friction and increase the number of market participants, and therefore increase the demand for housing. Greater price changes would be expected in regions where the housing supply is inelastic. To determine the validity of this proposal, we use the house supply elasticity data in Saiz (2010), which include the 95 largest MSAs at the end of 2000. There are 102 matching MSAs/MSADs with our sample (seven of the MSAs in Saiz (2010) match two of the MSADs in our study). We then split the 102 matching MSAs by using an average supply elasticity of 1.9005 as the cutoff value. There are 44 MSAs and 58 MSAs in the high and low house supply elasticity groups, respectively. In Table 5, we test the difference between these two groups by adding a dummy variable, *High Elasticity*, which equals 1 if the observation belongs to the high house supply elasticity group and zero otherwise. The regression results are reported in Panel A, and the aggregated coefficients are reported in Panel B for ease of comparison. We also relax the assumption that the control variables must have the same influence on both elasticity groups by dropping the interaction terms and repeating Models (3) and (4) on these two groups respectively. The results are shown in Panel C.

The results of Models (1) to (3) show that the bank credit supply is more influential for regions with inelastic house supply. According to Panel B of Table 5, the coefficients of lagged log(*Tot RE Loan per capita*) for the low supply elasticity group (–0.175, –0.145, and –0.166 in Models (1) to (3), respectively) and the high elasticity group (–0.097, –0.073, and –0.083) are consistent across the different model specifications. The influence of on-balance sheet credit supply on the housing markets in MSAs with an inelastic house supply is about twice that in MSAs with an elastic house supply. When we further differentiate between the influence of on-balance sheet credit supply from the off-balance sheet credit supply in Model (4), the regression results indicate that off-balance sheet credit supply is the dominating source of liquidity creation for the low supply elasticity group, while the other two components, on-balance sheet credit supply and funding-side liquidity creation, are more critical for the high supply elasticity group. A possible explanation is that the MSAs with an inelastic supply are also more developed in non-traditional financial products and have a greater large bank presence. Therefore, they can rely on wider sources of funding from off-balance sheet credits. On the other hand, more traditional liquidity creation is favored in MSAs with a more elastic housing supply. Hence, the result of the dominance of off-balance sheet credit from non-traditional instruments is mainly due to the effects from the MSAs with inelastic housing supplies. As Panel C shows, the same arguments still hold even when we allow the coefficients of the control variables to differ across the two groups.

Table 5 On Different Supply Elasticity Groups

This table presents the fixed effect model regression results. The sample is divided into low and high house supply elasticity groups. House supply elasticity data is obtained from Saiz (2010), with 102 MSAs that match the list in Saiz (2010). Low supply elasticity group includes MSAs in which house supply elasticity is less than the average value of 1.9005. In Panel A, we add the interaction terms, in which *High Elasticity* equals the unit value if the observation belongs to the high house supply elasticity group and zero otherwise. In Panel B, we report the aggregated coefficients (based on *F*-statistics) for ease of comparison. In Panel C, we drop the interaction terms and repeat Models (3) and (4) on the high and low elasticity groups respectively. Standard errors, which are clustered at the MSA level, are reported in parentheses. *, **, *** denote significance at the 10%, 5% and 1% levels, respectively.

Panel A: Differences between Low and High House Supply Elasticity Groups

Dependent Variable: log(*Rent*/*Price*)	(1)	(2)	(3)	(4)
log(*Tot RE Loan per capita*)$_{t-1}$	-0.175***	-0.145***	-0.166***	
	(0.027)	(0.028)	(0.026)	
log(*OnBS RE Loan per capita*)$_{t-1}$				0.058*
				(0.029)
log(*OffBS RE Loan per capita*)$_{t-1}$				-0.168***
				(0.019)
log(*Funding LC per capita*)$_{t-1}$	0.068***	0.052**	0.067***	-0.006
	(0.024)	(0.023)	(0.024)	(0.026)
log(*Tot RE Loan per capita*)$_{t-1}$× *High Elasticity*	0.078***	0.072**	0.083***	
	(0.030)	(0.028)	(0.027)	
log(*OnBS RE Loan per capita*)$_{t-1}$× *High Elasticity*				-0.129***
				(0.037)
log(*OffBS RE Loan per capita*)$_{t-1}$ × *High Elasticity*				0.153***
				(0.023)
log(*Funding LC per capita*)$_{t-1}$× *High Elasticity*	-0.005	0.003	-0.003	0.071**
	(0.030)	(0.028)	(0.030)	(0.033)
r_{t-1}		0.859***	0.904***	0.155
		(0.271)	(0.278)	(0.223)
Term Spread$_{t-1}$		2.418***	1.690***	1.466***
		(0.255)	(0.254)	(0.234)
*Avg*Δlog(*Rent*)$_{t-1}$		-0.776***	-0.832***	-0.637***
		(0.229)	(0.227)	(0.204)
Δlog(*Income per capita*)$_{t-1}$			-0.305***	-0.171
			(0.115)	(0.104)
Δlog(*Population*)$_{t-1}$			-2.039*	-1.978**
			(1.044)	(0.957)
Δlog(*Employment*)$_{t-1}$			-0.536***	-0.788***
			(0.202)	(0.209)
Constant	4.820***	4.627***	4.696***	4.621***
	(0.181)	(0.200)	(0.175)	(0.171)
Observations	2,845	2,845	2,845	2,840
Adj. R-squared	0.168	0.211	0.235	0.307
MSAD FE	YES	YES	YES	YES

Panel B: Aggregate Coefficients of Panel B.

Dependent Variable: log(*Rent*/*Price*)	(1)	(2)	(3)	(4)
Low Supply Elasticity Group				
log(*Tot RE Loan per capita*)$_{t-1}$	-0.175***	-0.145***	-0.166***	
log(*OnBS RE Loan per capita*)$_{t-1}$				0.058*
log(*OffBS RE Loan per capita*)$_{t-1}$				-0.168***
log(*Funding LC per capita*)$_{t-1}$	0.068***	0.052**	0.067***	-0.006
High Supply Elasticity Group				
log(*Tot RE Loan per capita*)$_{t-1}$	-0.097***	-0.073***	-0.083***	
log(*OnBS RE Loan per capita*)$_{t-1}$				-0.071***
log(*OffBS RE Loan per capita*)$_{t-1}$				-0.015
log(*Funding LC per capita*)$_{t-1}$	0.063***	0.055***	0.064***	0.065***

Panel C: Separate Regressions on Low and High House Supply Elasticity Groups

Dependent Variable: log(*Rent*/*Price*)	Low Elasticity Group		High Elasticity Group	
	(1)	(2)	(3)	(4)
log(*Tot RE Loan per capita*)$_{t-1}$	-0.147***		-0.105***	
	(0.025)		(0.013)	
log(*OnBS RE Loan per capita*)$_{t-1}$		0.054*		-0.072***
		(0.028)		(0.021)
log(*OffBS RE Loan per capita*)$_{t-1}$		-0.160***		-0.019
		(0.020)		(0.011)
log(*Funding LC per capita*)$_{t-1}$	0.076***	0.007	0.049**	0.045**
	(0.026)	(0.029)	(0.019)	(0.017)
r_{t-1}	1.827***	0.534*	-0.180	-0.147
	(0.325)	(0.295)	(0.339)	(0.339)
Term Spread$_{t-1}$	1.704***	1.326***	1.595***	1.636***
	(0.380)	(0.334)	(0.271)	(0.276)
*Avg*Δlog(*Rent*)$_{t-1}$	-1.268***	-1.004***	-0.191	-0.157
	(0.358)	(0.325)	(0.204)	(0.210)
Δlog(*Income per capita*)$_{t-1}$	-0.611***	-0.391**	0.132	0.163
	(0.168)	(0.155)	(0.099)	(0.101)
Δlog(*Population*)$_{t-1}$	-1.618*	-1.452*	-4.566***	-4.863***
	(0.920)	(0.807)	(1.258)	(1.330)
Δlog(*Employment*)$_{t-1}$	-0.777***	-1.205***	0.073	0.075
	(0.270)	(0.274)	(0.226)	(0.230)
Constant	4.795***	4.784***	4.597***	4.459***
	(0.253)	(0.261)	(0.166)	(0.159)
Observations	1,620	1,620	1,225	1,220
Adj. R-squared	0.272	0.355	0.229	0.223
MSAD FE	YES	YES	YES	YES

4.4 Effects of Liquidity Creation on Bank Size

Berger and Sedunov (2017) provide empirical evidence that small banks influence aggregate economic output through on-balance sheet liquidity creation, while large banks influence the aggregate economic output through the more sophisticated off-balance sheet liquidity creation. To test whether this is also true in housing markets, we classify all MSAs into three equal groups in each year based on the proportion of residential real estate loans provided by large banks (with total assets above US$1 billion, as in Berger and Sedunov (2017)). We then repeat Models (3) and (4) of Table 2 on these three groups separately.

Our empirical results in Table 6 suggest that off-balance credit supply is more important for MSAs where large banks play a major role (a strong presence of large banks), while on-balance sheet credit supply and funding-side liquidity creation are more critical for MSAs where large banks have a less dominating presence (a week presence of large banks). One possible reason is that large banks are better able to securitize mortgage loans, and tend to loosen screening standards for securitizable mortgage loans during housing booms (Keys et al. 2010), thus driving up house prices relative to rent. Hence, the negative relationship between off-balance sheet credit supply and rent-to-price ratio is particularly prominent in the group that is dominated by large banks.

4.5 Intertemporal Dynamic Effects of Different Components of Liquidity Creation

As a robustness check, we examine the intertemporal dynamics of the relationship among three different components of liquidity creation and rent-to-price ratio for up to four years in this section, to see how far the "memory" of the effect is carried forward. We regress the rent-to-price ratio on one-year, two-year, three-year and four-year lagged independent variables and provide the regression results in Table 7. The magnitude of the coefficients of log(*Tot RE Loan per capita*) and log(*Funding LC per capita*) lagged two years is reduced by 31.37% (i.e. 0.105/0.153−1) and 50.68% (i.e. 0.036/0.073−1) respectively compared to the 1 year lag. In Panel B, we further differentiate the influence of the on-balance sheet credit supply from that of the off-balance sheet credit supply. The coefficient of log(*OnBS RE Loan per capita*) and log(*OffBS RE Loan per capita*) lagged two years is reduced by 38.46% (i.e. 0.048/0.078−1) and 25.00% (i.e. 0.033/0.044−1), respectively, when compared to the more recent 1 year lag. The coefficient of the on-balance sheet credit supply of the previous four years relative to that of the previous year becomes insignificant while the coefficient of the off-balance sheet credit supply decreases by 72.73% (i.e. 0.012/0.044−1). These results suggest that the influence of off-balance sheet credit supply has more longevity and is more persistent.

Table 6 Large Banks versus Small Banks

This table presents the fixed effect model regression results. For each year, we separate all MSAs into three groups—those with weak, moderate, and strong presence of large banks —using the 33rd and 66th percentiles of the distribution of the proportion of total credit supply provided by the large banks. The group with weak presence of large banks include MSAs in which large banks provide the lowest proportion of residential loans. We repeat Models (3) and (4) of Table 2 on each group. Standard errors, which are clustered at the MSA level, are reported in parentheses. *, **, *** denote significance at the 10%, 5% and 1% levels, respectively.

	Weak Presence of Large Banks		Moderate Presence of Large Banks		Strong Presence of Large Banks	
Dependent Variable: log(*Rent*/*Price*)	(1)	(2)	(4)	(5)	(7)	(8)
log(*Tot RE Loan per capita*)$_{t-1}$	-0.193***		-0.178***		-0.132***	
	(0.016)		(0.013)		(0.013)	
log(*OnBS RE Loan per capita*)$_{t-1}$		-0.100***		-0.098***		-0.004
		(0.022)		(0.020)		(0.020)
log(*OffBS RE Loan per capita*)$_{t-1}$		-0.045***		-0.042***		-0.105***
		(0.010)		(0.011)		(0.018)
log(*Funding LC per capita*)$_{t-1}$	0.098***	0.084***	0.066***	0.047***	0.057***	0.021
	(0.019)	(0.019)	(0.017)	(0.017)	(0.014)	(0.013)
r_{t-1}	-0.114	-0.388*	0.223	0.116	1.386***	0.605***
	(0.193)	(0.221)	(0.206)	(0.212)	(0.232)	(0.232)
Term Spread$_{t-1}$	1.276***	1.276***	0.815***	1.032***	1.970***	1.618***
	(0.215)	(0.214)	(0.216)	(0.215)	(0.255)	(0.253)
*Avg*Δlog(*Rent*)$_{t-1}$	0.459***	0.531***	0.076	0.104	-0.913***	-0.718***
	(0.134)	(0.144)	(0.151)	(0.157)	(0.205)	(0.207)

(*Continued…*)

(Table 6 Continued)

Dependent Variable: log(*Rent*/*Price*)	Weak Presence of Large Banks (1)	(2)	Moderate Presence of Large Banks (4)	(5)	Strong Presence of Large Banks (7)	(8)
Δlog(*Income per capita*)$_{t-1}$	-0.400***	-0.284***	-0.373***	-0.309***	-0.306***	-0.210**
	(0.096)	(0.100)	(0.102)	(0.098)	(0.093)	(0.082)
Δlog(*Population*)$_{t-1}$	-3.472***	-3.529***	-2.304***	-2.294***	-3.024***	-2.622***
	(0.604)	(0.629)	(0.809)	(0.821)	(0.625)	(0.599)
Δlog(*Employment*)$_{t-1}$	0.243	0.089	-0.243	-0.283*	-0.837***	-1.099***
	(0.155)	(0.162)	(0.159)	(0.159)	(0.182)	(0.177)
Constant	4.794***	4.385***	5.018***	4.757***	4.777***	4.711***
	(0.171)	(0.170)	(0.181)	(0.163)	(0.136)	(0.127)
Observations	3,629	3,614	3,688	3,661	3,794	3,789
Adj. R-squared	0.232	0.244	0.209	0.209	0.215	0.259
MSA FE	YES	YES	YES	YES	YES	YES

Table 7 Dynamic Effects of Different Components of Liquidity Creation

This table presents the fixed effect model regression results. In Panel A, we repeat Model (3) of Table 2 on one, two, three, and four year lagged key independent variables. In Panel B, we repeat Model (4) of Table 2 on lagged key independent variables. Standard errors, which are clustered at the MSA level, are reported in parentheses. *, **, *** denote significance at the 10%, 5% and 1% levels, respectively.

Panel A: Dynamic Effects of Model (3) of Table 2

Dependent Variable: log(*Rent*/*Price*)	(1)	(2)	(3)	(4)
log(*Tot RE Loan per capita*)$_{t-1}$	-0.153***			
	(0.009)			
log(*Tot RE Loan per capita*)$_{t-2}$		-0.105***		
		(0.008)		
log(*Tot RE Loan per capita*)$_{t-3}$			-0.063***	
			(0.008)	
log(*Tot RE Loan per capita*)$_{t-4}$				-0.027***
				(0.008)
log(*Funding LC per capita*)$_{t-1}$	0.073***			
	(0.010)			
log(*Funding LC per capita*)$_{t-2}$		0.036***		
		(0.009)		
log(*Funding LC per capita*)$_{t-3}$			0.011	
			(0.009)	
log(*Funding LC per capita*)$_{t-4}$				-0.003
				(0.010)
r_{t-1}	0.584***	0.727***	0.923***	1.093***
	(0.148)	(0.151)	(0.151)	(0.151)
Term Spread$_{t-1}$	1.571***	2.255***	2.428***	2.084***
	(0.118)	(0.110)	(0.100)	(0.096)
*Avg*Δlog(*Rent*)$_{t-1}$	-0.211**	-0.319***	-0.381***	-0.396***
	(0.103)	(0.104)	(0.108)	(0.113)
Δlog(*Income per capita*)$_{t-1}$	-0.420***	-0.250***	-0.111**	-0.199***
	(0.063)	(0.055)	(0.056)	(0.058)
Δlog(*Population*)$_{t-1}$	-2.888***	-3.013***	-3.288***	-3.704***
	(0.470)	(0.552)	(0.619)	(0.692)
Δlog(*Employment*)$_{t-1}$	-0.295***	-0.346***	-0.248**	0.023
	(0.104)	(0.098)	(0.104)	(0.110)
Constant	4.739***	4.626***	4.472***	4.282***
	(0.097)	(0.096)	(0.092)	(0.087)
Observations	11,111	10,749	10,369	9,975
Adj. R-squared	0.203	0.157	0.118	0.085
MSAD FE	YES	YES	YES	YES

Panel B: Dynamic Effects of Model (4) of Table 2

Dependent Variable: log(*Rent*/*Price*)	(1)	(2)	(3)	(4)
log(*OnBS RE Loan per capita*)$_{t-1}$	-0.078***			
	(0.013)			
log(*OnBS RE Loan per capita*)$_{t-2}$		-0.048***		
		(0.011)		
log(*OnBS RE Loan per capita*)$_{t-3}$			-0.026**	
			(0.011)	
log(*OnBS RE Loan per capita*)$_{t-4}$				-0.008
				(0.010)
log(*OffBS RE Loan per capita*)$_{t-1}$	-0.044***			
	(0.008)			
log(*OffBS RE Loan per capita*)$_{t-2}$		-0.033***		
		(0.006)		
log(*OffBS RE Loan per capita*)$_{t-3}$			-0.021***	
			(0.005)	
log(*OffBS RE Loan per capita*)$_{t-4}$				-0.012***
				(0.004)
log(*Funding LC per capita*)$_{t-1}$	0.052***			
	(0.010)			
log(*Funding LC per capita*)$_{t-2}$		0.020**		
		(0.009)		
log(*Funding LC per capita*)$_{t-3}$			0.001	
			(0.010)	
log(*Funding LC per capita*)$_{t-4}$				-0.008
				(0.011)
r_{t-1}	0.329**	0.508***	0.774***	0.996***
	(0.153)	(0.149)	(0.146)	(0.143)
Term Spread$_{t-1}$	1.613***	2.276***	2.449***	2.125***
	(0.115)	(0.111)	(0.099)	(0.097)
*Avg*Δlog(*Rent*)$_{t-1}$	-0.111	-0.239**	-0.330***	-0.367***
	(0.103)	(0.105)	(0.109)	(0.114)
Δlog(*Income per capita*)$_{t-1}$	-0.344***	-0.215***	-0.105*	-0.185***
	(0.059)	(0.053)	(0.056)	(0.057)
Δlog(*Population*)$_{t-1}$	-2.823***	-2.961***	-3.269***	-3.697***
	(0.473)	(0.550)	(0.623)	(0.698)
Δlog(*Employment*)$_{t-1}$	-0.385***	-0.389***	-0.269**	-0.014
	(0.106)	(0.103)	(0.107)	(0.111)
Constant	4.553***	4.484***	4.374***	4.232***
	(0.086)	(0.088)	(0.087)	(0.085)
Observations	11,064	10,701	10,320	9,926
Adj. R-squared	0.209	0.162	0.121	0.087
MSA FE	YES	YES	YES	YES

4.6 Alternative Proxies for Bank Influence

As discussed in the previous sections, both on-balance sheet and off-balance sheet credit supply boost housing markets (i.e. reduce the rent-to-price ratio), while funding-side liquidity creation inhibits them. Here, we ask whether credit supply can more support the housing market if it is financed by illiquid and stable funding resources. We use three additional proxies, log(*Tot RE Loan*/*Funding LC*), log(*OnBS RE Loan*/*Funding LC*) and log(*OffBS RE Loan/Funding LC*). A higher level of *RE Loan*/*Funding LC* indicates that more housing loans are covered by illiquid funding resources (e.g. equities). The same rationale applies to the two other proxies.

In Panel A of Table 8, we regress the log rent-to-price ratio on these three proxies by using state-level data. The regression results show that a state tends to have a low rent-to-price ratio (log(*Rent*/*Price*)) when its banks rely on relatively illiquid funding resources to finance housing projects (high log(*Tot RE Loan*/*Funding LC*)). This echoes previous findings in that activities from the funding side to create liquidity is selected against housing loans, and therefore curb house prices relative to rents.

To alleviate the concern of potential reverse causality and measurement errors, we further adopt the Rice-Strahan index (see Rice and Strahan, 2010) as an instrument and adopt two-stage least square (2SLS) models. The Rice-Strahan index reflects the level of policy restrictions on bank interstate expansion between 1994 and 2005 and is not influenced by economic conditions (Kroszner and Strahan, 1999). The index ranges between 0 and 4; and a higher value denotes tighter interstate restrictions of a state. The results are shown in Panel B.

As the first stage results shows, the Rice-Strahan index is negatively and significantly correlated with all three liquidity creation proxies, and the Kleibergen-Paap *F*-statistics are larger than the threshold value of 16.34 (Stock et al. 2002). Both tests reject the null hypothesis that the index is a weak instrument. The second-stage regression results show that a state with banks that rely on illiquid funding resources to provide housing loans (high log(*Tot RE Loan*/*Funding LC*)) experiences higher house prices relative to rents (low log(*Rent*/*Price*)). It should be noted that the R-squared from the 2SLS regressions has no statistical meaning (Sribney et al., 2005), and negative R-squared is a common phenomenon in 2SLS regressions (Lu and Wedig, 2013). Hence, the negative R-squared in Models (1) and (2) can be ignored. Besides, larger 2SLS coefficients relative to the ordinary least squares (OLS) coefficients are commonly found in the literature (see for e.g. Berger and Sedunov, 2017).

Table 8 Alternative Proxies for Bank Influence

Since the *Rice-Strahan* index is a state-level index while MSA could be multistate (e.g. New York-Newark-Jersey City, NY-NH-PA), we use state-level data in both panels to enhance comparability. Panel A presents the fixed effect model regression results. The dependent variable is log(*Rent*/*Price*), and independent variables are described in Table 1. The sample period is 1990-2018. Panel B reports the two-stage least square regression (2SLS) results. The instrument variable is the *Rice-Strahan index*. The sample period is 1994-2005, since the *Rice-Strahan index* is constructed for that period. Standard errors, which are clustered at the state level, are reported in parentheses. *, **, *** denote significance at the 10%, 5% and 1% levels, respectively.

Panel A: Fixed Effect Results Using State-Level Data

Dependent Variable: log(*Rent*/*Price*)	(1)	(2)	(3)	(4)
log(*Tot RE Loan*/*Funding LC*)$_{t-1}$	-0.118***			
	(0.027)			
log(*OnBS RE Loan*/*Funding LC*)$_{t-1}$		-0.118***		-0.008
		(0.026)		(0.029)
log(*OffBS RE Loan*/*Funding LC*)$_{t-1}$			-0.083***	-0.080***
			(0.014)	(0.018)
r_{t-1}	1.941***	2.244***	1.202***	1.209***
	(0.450)	(0.439)	(0.449)	(0.447)
Term Spread$_{t-1}$	0.985***	0.722***	0.779***	0.755***
	(0.279)	(0.268)	(0.261)	(0.262)
*Avg*Δlog(*Rent*)$_{t-1}$	-1.948***	-1.915***	-1.643***	-1.649***
	(0.310)	(0.285)	(0.321)	(0.319)
Δlog(*Income per capita*)$_{t-1}$	-0.328**	-0.367**	-0.135	-0.136
	(0.161)	(0.161)	(0.164)	(0.165)
Δlog(*Population*)$_{t-1}$	-5.065***	-5.404***	-4.389***	-4.411***
	(1.469)	(1.400)	(1.514)	(1.520)
Δlog(*Employment*)$_{t-1}$	-0.493	-0.378	-0.898***	-0.910***
	(0.314)	(0.310)	(0.328)	(0.327)
Constant	3.503***	3.487***	3.347***	3.353***
	(0.017)	(0.013)	(0.024)	(0.033)
Observations	1,421	1,472	1,421	1,421
Adj. R-squared	0.359	0.351	0.399	0.399
State FE	YES	YES	YES	YES

Panel B: 2SLS Regression Results Using State-Level Data

First-Stage Results	(1) log(*Tot RE Loan /Funding LC*)	(2) log(*OnBS RE Loan /Funding LC*)	(3) log(*OffBS RE Loan /Funding LC*)
Rice-Strahan index$_{t-1}$	-0.054***	-0.047***	-0.084***
	(0.011)	(0.011)	(0.016)
r_{t-1}	-10.757***	-8.615***	-26.693***
	(1.085)	(1.076)	(1.689)
Term Spread$_{t-1}$	-3.139***	-3.842***	-0.153
	(1.104)	(1.106)	(1.873)
*Avg*Δlog(*Rent*)$_{t-1}$	0.381	0.212	2.685**
	(0.676)	(0.654)	(1.135)
Δlog(*Income per capita*)$_{t-1}$	1.115	1.046	2.602*
	(0.941)	(0.937)	(1.524)
Δlog(*Population*)$_{t-1}$	-5.781	-5.925	-3.287
	(4.045)	(4.022)	(6.406)
Δlog(*Employment*)$_{t-1}$	-4.377**	-4.124**	-9.530***
	(1.703)	(1.728)	(2.267)
Kleibergen-Paap *F*-stat	25.15	18.45	27.84
Second Stage Results	(1) log(*Rent*/*Price*)	(2) log(*Rent*/*Price*)	(3) log(*Rent*/*Price*)
log(*Tot RE Loan*/*Funding LC*)$_{t-1}$	-0.400***		
	(0.106)		
log(*OnBS RE Loan*/*Funding LC*)$_{t-1}$		-0.461***	
		(0.136)	
log(*OffBS RE Loan*/*Funding LC*)$_{t-1}$			-0.256***
			(0.062)
r_{t-1}	1.901	2.234	-0.643
	(1.419)	(1.487)	(1.909)
Term Spread$_{t-1}$	-4.299***	-4.814***	-3.083***
	(0.668)	(0.823)	(0.591)
*Avg*Δlog(*Rent*)$_{t-1}$	-1.501***	-1.556***	-0.965**
	(0.362)	(0.385)	(0.441)
Δlog(*Income per capita*)$_{t-1}$	0.112	0.148	0.333
	(0.479)	(0.541)	(0.512)
Δlog(*Population*)$_{t-1}$	-2.248	-2.666	-0.779
	(2.029)	(2.262)	(2.029)
Δlog(*Employment*)$_{t-1}$	-3.017***	-3.166***	-3.711***
	(0.987)	(1.151)	(0.985)
Observations	608	608	608
Number of States	51	51	51
R-squared	-0.018	-0.269	0.068

5. Conclusions

The marked boom-bust housing cycle over the last three decades has attracted renewed attention on why and how house price departs from its fundamental value. In this paper, we adopt the theoretical framework on fundamental house price to rent as per Campbell et al. (2009) and Plazzi et al. (2010) to investigate how different components of bank liquidity creation influence housing prices in 401 MSAs/MSADs and 51 states over the period of 1990-2018.

We show that not all liquidity creation activities from banks boost the housing markets. Asset-side and off-balance sheet liquidity creation activities drive down the rent-to-price ratio, thus suggesting that house prices can persistently deviate from their fundamental value due to bank credit supply (Di Maggio and Kermani, 2017; Keys et al. 2010). On the contrary, the test results of funding-side liquidity creation show that banks that rely heavily on liquid funding resources (e.g. demandable deposits and interbank loans) tend to behave more conservatively by providing credit only when they perceive house prices to be relatively undervalued (i.e. a large rent-to-price ratio).

Our findings have the following implications. First, given that liquidity creation actually affects the housing markets, regulatory bodies should not overlook the fact that banking regulations such as capital requirements influence not only bank stability but also the real economy (the housing markets in our study). Second, different components of liquidity creation have different, and sometimes opposite, influences on the housing markets as opposed to the general belief that liquidity creation always boosts housing markets by providing more funding to homebuyers. We find that, contrary to asset-side liquidity creation, funding-side liquidity creation actually dampens the price momentum of housing markets. This indicates that the strategy of shifting toward funding-side liquidity creation (as in the U.S. after the GFC) is less likely to inflate asset bubbles than a strategy that focuses on asset-side or off-balance sheet liquidity creation. Finally, housing prices in MSAs with banks that provide more lenient credit before crises tend to experience larger corrections during the crises; these banks tend to be in MSAs with a relatively inelastic housing supply, and are often larger banks that use more sophisticated off-balance sheet liquidity creation.

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Appendices

Appendix I Theoretical Framework

As specified in Equation (1) of Section 2, we define the one-period real gross return of the housing market *i* at time *t*+1 following Campbell et al. (2009) and Plazzi et al. (2010) as:

$$\Phi_{i,t+1} \equiv \left(Price_{i,t+1} + Rent_{i,t+1}\right)/Price_{i,t} \qquad \text{(I.1)}$$

As both housing prices and rents are strictly positive, we could take the natural log on both sides and rewrite the equation as:

$$\begin{aligned}\log\left(\Phi_{i,t+1}\right) = {} & \log\left(Price_{i,t+1}\right) \\ & + \log\left(1 + \exp\left(\log\left(Rent_{i,t+1}/Price_{i,t+1}\right)\right)\right) \\ & - \log\left(Price_{i,t}\right)\end{aligned} \qquad \text{(I.2)}$$

We define the log real gross return, log price, log rent, and log rent-to-price ratio as $\varphi_{i,t+1} \equiv \log\left(\Phi_{i,t+1}\right)$, $p_{i,t+1} \equiv \log\left(Price_{i,t+1}\right)$, $r_{i,t+1} \equiv \log\left(Rent_{i,t+1}\right)$ and $\delta_{i,t+1} \equiv r_{i,t+1} - p_{i,t+1}$, respectively. Equation (I.2) then becomes:

$$\begin{aligned}\varphi_{i,t+1} & = p_{i,t+1} + \log\left(1 + \exp\left(r_{i,t+1} - p_{i,t+1}\right)\right) - p_{i,t} \\ & = p_{i,t+1} - r_{i,t+1} + \log\left(1 + \exp\left(r_{i,t+1} - p_{i,t+1}\right)\right) - p_{i,t} \\ & \quad + r_{i,t} + \left(r_{i,t+1} - r_{i,t}\right) \\ & = -\delta_{i,t+1} + \log\left(1 + \exp\left(\delta_{i,t+1}\right)\right) + \delta_{i,t} + \Delta r_{i,t+1}\end{aligned} \qquad \text{(I.3)}$$

We then follow Campbell and Shiller (1988) and calculate the first-order Taylor approximation at the point $\delta_{i,t+1} = \delta_{i,t} = \delta$ and $\Delta r_{i,t+1} = g$, where δ and g denote the long-run average rent-to-price ratio and rent growth rate, respectively. We then obtain the equation:

$$\begin{aligned}\varphi_{i,t+1} \simeq {} & -\delta + \log(1 + \exp(\delta)) + \delta + g \\ & + \left(-1 + \frac{\exp(\delta)}{1 + \exp(\delta)}\right)\left(\delta_{i,t+1} - \delta\right) \\ & + \left(\delta_{i,t} - \delta\right) + \left(\Delta r_{i,t+1} - g\right)\end{aligned} \qquad \text{(I.4)}$$

Since $\delta_{i,t+1} \equiv r_{i,t+1} - p_{i,t+1}$, the right-hand side of Equation (I.4) can be rewritten as:

$$\begin{aligned}\varphi_{i,t+1} \simeq {} & \log(1 + \exp(\delta)) \\ & -(1 + \exp(\delta))^{-1}\left(r_{i,t+1} - p_{i,t+1} - \delta\right) \\ & -p_{i,t} - \delta + r_{i,t+1}\end{aligned} \qquad \text{(I.5)}$$

Let $\rho \equiv (1+\exp(\delta))^{-1}$ and $\kappa \equiv -\log(\rho) - (1-\rho)\delta = -\log(\rho) - (1-\rho)\log(1/\rho - 1)$, we could derive Equation (2) of Section 2, as follows:

$$\begin{aligned}\varphi_{i,t+1} &\simeq -\log(\rho) - (1-\rho)\delta + \rho p_{i,t+1} + (1-\rho) r_{i,t+1} - p_{i,t} \\ &= \kappa + \rho p_{i,t+1} + (1-\rho) r_{i,t+1} - p_{i,t}\end{aligned} \tag{I.6}$$

To solve this equation forward, we rewrite Equation (I.6) as $\varphi_{i,t+1} \simeq \kappa - \rho(r_{i,t+1} - p_{i,t+1}) + (r_{i,t} - p_{i,t}) + r_{i,t+1} - r_{i,t} = \kappa - \rho\delta_{i,t+1} + \delta_{i,t} + \Delta r_{i,t+1}$, and get:

$$\begin{cases} \delta_{i,t} - \rho\delta_{i,t+1} \simeq -\kappa + \varphi_{i,t+1} - \Delta r_{i,t+1} \\ \rho\delta_{i,t+1} - \rho^2\delta_{i,t+2} \simeq -\rho\kappa + \rho\varphi_{i,t+2} - \rho\Delta r_{i,t+2} \\ \cdots \\ \rho^N\delta_{i,t+N} - \rho^{N+1}\delta_{i,t+1+N} \simeq -\rho^N\kappa + \rho^N\varphi_{i,t+1+N} - \rho^N\Delta r_{i,t+1+N} \\ \cdots \end{cases} \tag{I.7}$$

After imposing the terminal condition that $\lim_{j\to\infty} \rho^j \delta_{i,t+j} = 0$ to avoid the presence of rational bubbles, we obtain Equation (3) in Section 2, as the following equation shows:

$$\begin{aligned} E_t[\delta_{i,t}] = \delta_{i,t} &\simeq -\sum_{j=0}^{\infty}\rho^j\kappa + E_t\left[\sum_{j=0}^{\infty}\rho^j\varphi_{i,t+1+j}\right] \\ &\quad - E_t\left[\sum_{j=0}^{\infty}\rho^j\Delta r_{i,t+1+j}\right] \\ &= -\frac{\kappa}{1-\rho} + E_t\left[\sum_{j=0}^{\infty}\rho^j\varphi_{i,t+1+j}\right] \\ &\quad - E_t\left[\sum_{j=0}^{\infty}\rho^j\Delta r_{i,t+1+j}\right] \end{aligned} \tag{I.8}$$

Appendix II Robustness Checks of Table 2

This table reports the fixed effect model regression results. In Models (1) and (2), we add the log ratio between total residential real estate loans and total assets, log(*Tot RE Loan/Assets*). In Models (3) and (4), we replace funding-side liquidity creation with two alternative measures. log(*Demand Deposits/Tot Deposits*) denotes the log ratio between demand and total deposits, and log(*Tot Deposits/Assets*) is the log ratio between total deposits and assets (i.e. total funding resources). Standard errors, which are clustered at the MSA level, are reported in parentheses. *, **, *** denote significance at the 10%, 5% and 1% levels, respectively.

Dependent Variable: log(*Rent/Price*)	(1)	(2)	(3)	(4)
log(*Tot RE Loan per capita*)$_{t-1}$	-0.131***		-0.089***	
	(0.010)		(0.010)	
log(*OnBS RE Loan per capita*)$_{t-1}$		-0.055***		-0.036***
		(0.013)		(0.012)
log(*OffBS RE Loan per capita*)$_{t-1}$		-0.041***		-0.036***
		(0.008)		(0.007)
log(*Tot RE Loan/Assets*)$_{t-1}$	-0.055***	-0.067***	-0.076***	-0.074***
	(0.015)	(0.016)	(0.019)	(0.018)
log(*Funding LC per capita*)$_{t-1}$	0.057***	0.034***		
	(0.011)	(0.011)		
log(*Demand Deposits/Tot Deposits*)$_{t-1}$			0.176***	0.193***
			(0.019)	(0.019)
log(*Tot Deposits/Assets*)$_{t-1}$			0.321***	0.282***
			(0.051)	(0.048)
r_{t-1}	0.608***	0.356**	1.602***	1.351***
	(0.147)	(0.152)	(0.135)	(0.134)
Term Spread$_{t-1}$	1.712***	1.774***	0.458***	0.360**
	(0.128)	(0.127)	(0.164)	(0.160)
*Avg*Δlog(*Rent*)$_{t-1}$	-0.217**	-0.121	-0.409***	-0.338***
	(0.104)	(0.104)	(0.103)	(0.100)
Δlog(*Income per capita*)$_{t-1}$	-0.423***	-0.352***	-0.529***	-0.489***
	(0.063)	(0.059)	(0.075)	(0.072)
Δlog(*Population*)$_{t-1}$	-2.805***	-2.721***	-2.333***	-2.229***
	(0.461)	(0.462)	(0.397)	(0.395)
Δlog(*Employment*)$_{t-1}$	-0.281***	-0.368***	-0.181*	-0.305***
	(0.104)	(0.106)	(0.107)	(0.107)
Constant	4.597***	4.394***	4.867***	4.650***
	(0.112)	(0.102)	(0.110)	(0.103)
Observations	11,111	11,064	11,139	11,092
Adjusted R-squared	0.207	0.214	0.275	0.283
MSAD FE	YES	YES	YES	YES