The Propagation of Local Credit Shocks: Evidence from Hurricane Katrina

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Abstract

A local credit shock, induced by hurricane Katrina, propagated through banks' internal networks to produce real and credit markets' effects in distant regions. Driven by abnormal mortgage and housing demand in Katrina-hit areas, financially constrained multi-market banks re-allocated resources towards the damaged areas leading to a credit tightening in the undamaged local markets. Depending on their housing supply elasticity, local housing markets in the undamaged regions responded to this credit disruption with a mix of housing prices and housing supply declines. These spillovers depended on undamaged markets' financial linkages to disaster areas. In the undamaged regions, community banks, being local and unexposed to disaster areas, partially insulated their markets from these spillovers.

JEL Codes: G21, G32, H84 and R31

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1 Introduction

How do local shocks propagate through an interconnected financial system, and what are the real market effects of these spillovers? I show that a credit shock, induced by hurricane Katrina in a small and contained area, propagated through the financial system to lead to persistent and significant effects on housing prices, residential development and credit supply across the United States. Financial linkages served as a channel for spillovers from disaster areas towards the undamaged ones. The novelty of this paper, compared to the literature on the transmission of credit shocks, is the documentation of sizeable credit and real markets' effects of these spillovers in regions that are very distant to the location of the physical shock of the hurricane. Katrina induced a one-off drop in housing price growth, a persistently lower house price level, and a negative shock to residential development in regions that were undamaged by the storm and are geographically distant to disaster areas. These spillovers were proportional to the strength of the financial ties between these regions and storm-affected areas. This paper is the first to provide a detailed demonstration of the transmission mechanism of financial spillovers between regions.

I document the following causal chain. First, in the aftermath of a natural disaster, insurance, federal assistance and reconstruction needs create a significant housing and mortgage demand surge in the damaged areas [Cortés and Strahan 2017]. Regarding Katrina, I document a surge in construction and mortgage credit indicators in disaster areas immediately following the storm. This includes a surge in the number of building permits issued, an abnormal growth of the housing stock, loan origination volumes and housing prices in Katrina-damaged areas. In addition, I observe a surge in average loan approval rates in disaster areas compared to the neighboring intact ones. In fact, in September 2005, the Federal Reserve forecast the recovery process to contribute almost $\frac{1}{2}$ percentage point to the growth of real GDP in 2006, driven by the federal aid package.[1]

[1]Current Economic and Financial Conditions: Summary and Outlook. Prepared for the Federal Open Market Committee by the staff of the Board of Governors of the Federal Reserve, September 14, 2005. https:

Second, in response to this abnormal demand for housing and mortgages, financially constrained multi-market banks increased loan supply and market entry to disaster areas at the expense of the undamaged regions. This finding is supported by a positive interest rate differential between Louisiana and Mississippi, and the rest of the country, after the storm. Third, this re-allocation of resources towards disaster regions led to a credit tightening in the undamaged areas. In turn, this contraction put downward pressure on housing prices and dampened construction in the undamaged areas that had strong financial ties to Katrina-hit markets, starting immediately after the storm, exactly in the fourth quarter of 2005.

This causal chain is rationalized by the flow of capital within banks and the role of banks' headquarters in efficiently allocating resources between different areas. Financial institutions operating simultaneously in multiple local markets create financial linkages between these markets [Landier et al. 2017]. Local loan demand shocks could lead multi-market banks either to re-allocate resources towards the regions experiencing positive demand shocks, or away from the ones witnessing negative demand shocks [Berrospide et al. 2016]. I provide two complementary pieces of evidence supporting the hypothesis of bank's geographic re-allocation of resources, towards booming disaster areas and away from the undamaged ones. First, holding all banks' characteristics constant, banks headquartered outside of the Southern United States were, on average, 4.25 percentage points more likely to enter Katrina-hit local markets, than entering the undamaged regions in the U.S. in the post-Katrina period. Second, banks that had historically been present in Katrina areas abruptly reduced mortgage loan application approval rates in the undamaged areas immediately after Katrina, on average, by 1.24 percentage points, holding all undamaged local area characteristics constant including local demand.

To the extent that banks are financially constrained, profit maximization requires them to shift resources between projects based on their risk-adjusted returns; a *'winner-picking'* strategy, as framed by Stein (1997). This re-allocation is rationalized by three findings. Consistent with Giroud and Mueller

//www.federalreserve.gov/monetarypolicy/files/FOMC20050920gbpt120050914.pdf

(2015), financially unconstrained banks didn't substitute towards disaster areas after the storm. Second, there is evidence on higher post-storm mortgage interest rates in Louisiana and Mississippi relative to the rest of the country, consistent with the observed positive aggregate demand shock boosting construction and credit markets in disaster areas. Third, consistent with Gilje et al. (2016) and Chakraborty et al. (2016), securitization did not fully alleviate the constraints associated with the post-Katrina credit expansion in disaster areas. I document significant increases in the funding originated in disaster areas and retained on banks' balance sheets after Katrina. These points suggest that constrained banks took advantage of higher risk-adjusted returns in disaster markets, at the expense of their positions in the undamaged areas.

Having established these facts, I test the hypothesis that this re-allocation of resources, away from the undamaged areas, put downward pressure on housing prices and residential development in the undamaged regions. Using a measure of geographic financial linkages to disaster areas, I report a 0.89% post-storm decline in home values in the county with the average strength of financial linkages to Katrina-hit areas. I also report similar findings at the Core Based Statistical Area (CBSA) level. As shown in figure 1, housing price trends in the treatment and control groups of local markets (CBSAs) remained superimposed for an extended period of time prior to the exact timing of Katrina. Additionally, I exploit the heterogeneity between local markets in their housing supply elasticity to show that elastic markets responded to this credit disruption with smaller price declines and larger declines in construction.

[Figure 1 about here]

The identifying assumption is that, in the absence of Katrina, areas with different financial ties to disaster areas would have continued to trend similarly, in terms of housing prices and quantities. This assumption is supported by four findings. Housing price trends are superimposed for an extended period of time prior to Katrina. The divergence of trends occurred exactly in the fourth quarter of 2005, immediately after Katrina (late August 2005). Second, I report corroborating evidence on a banks' credit supply contraction in the undamaged regions, occurring simultaneously. Third, I document a simultaneous abnormal banks' market entry, mortgage origination and a construction boom in Katrina-damaged areas, immediately after the hurricane, consistent with the hypothesis of banks' geographic re-allocation. Fourth, these impacts hold in markets that are far away from Katrina-hit areas, which lessen concerns about potential confounders related to the storm such as labor markets spillovers. Consistent with a credit tightening in the undamaged regions, there is also evidence on an increase in local mortgage interest rates, after the storm, in the undamaged markets with strong financial ties to disaster areas relative to the ones with weak financial ties.

This paper identifies significant real market effects emanating from the propagation a climate-related shock through banks' Internal Capital Markets ICMs. For instance, Berrospide et al. (2016) show that multi-market banks reduced local mortgage lending in response to their exposure to mortgage distress in other distant markets during the 2007-09 crisis. Consistent with Stein (1997)'s '*winner-picking*' strategy, Chakraborty et al. (2018) find that banks exposed to booming housing markets allocate more resources to mortgage lending at the expense of commercial lending. ICMs are also a channel for international spillovers [Peek and Rosengren 1997, Cetorelli and Goldberg 2012 and Hale et al. 2020]. Peek and Rosengren (1997) identified a credit supply shock resulting from a credit tightening by Japanese banks operating in the U.S., in response to a collapse in Japanese equity markets in the early 1990s. Cortés and Strahan (2017) report evidence on disaster-induced local demand shocks leading small banks to re-allocate resources towards damaged areas. The propagation of local shocks within firms' internal networks was also documented for non-financial firms [Giroud and Mueller 2019].

The assumption behind these studies is that financial constraints make it costly for banks to raise external capital and limit their ability to pursue different investment opportunities simultaneously, leading them to re-allocate resources efficiently between projects, in search for higher yields. A body of literature attributes these constraints to informational frictions [Stein 1997, 1998]. Banks' financial constraints also attracted attention, regarding their relation to the bank lending channel of monetary policy transmission, including studies reporting evidence on financially constrained banks being more sensitive to monetary policy shocks [Ashcraft 2006, Kashyap and Stein 2000, Kishan and Opiela 2000]. My findings are also consistent with Gilje et al. (2016) and Chakraborty et al. (2016) who emphasize the limitations of securitization in alleviating banks' vulnerability to local funding shocks.

Second, I contribute to a literature on the causal link between credit supply and housing prices [Di Maggio and Kermani 2017, Favara and Imbs 2015, Loutskina and Strahan 2015]. Specifically, I exploit a plausibly exogenous variation between different local markets, emanating from the heterogeneity in their financial ties to Katrina-hit regions, to identify the effect on housing prices and construction.

This paper is relevant beyond the scope of hurricane Katrina. Shocks to local economies can create abnormally high or abnormally low local demand for construction and lending. These shocks could include extreme weather events or other economic fluctuations. In a financially integrated system, these local shocks can have geographically widespread and persistent repercussions. Understanding these linkages helps detect and rationalize the ramifications of these shocks beyond their initial boundaries.[2]

This study has three policy and business strategy implications. First, to the extent that banks are capital constrained, local shocks influence their credit supply decisions in other markets and in turn, housing markets' stability in these other markets. Policies aiming to support local housing markets on a regional basis, such as disaster aid, put unintended downward pressure on non-disaster markets by drawing resources away from them. Second, community banks play a housing market stabilization role. Being unexposed to distant shocks, they partially shield their local markets from external

[2]Regarding Katrina, this time-persistency and geographic ramifications seem to have been downplayed. In November 2005, the Federal Open Market Committee FOMC considered that the economic developments in disaster regions *'did not pose a more persistent threat to the overall economy'* and that the *'disruptions to aggregate economic activity and employment from the hurricanes were likely to be limited and temporary'*. Minutes of the meeting of the FOMC, 11/1/2005. Similar arguments were made in support of the decision to raise the Federal Fund Rate in September 2005, Minutes of the meeting of the FOMC, 9/20/2005.

shocks.[3] Finally, post-disaster reconstruction create significant opportunities for banks. In fact, banks strategically and swiftly responded by intensifying their entry to disaster markets, after Katrina.

2 Background, Data and Descriptive Analysis

I define Katrina-hit regions as the areas that were considered by the Federal Emergency Management Agency (FEMA) *'Major Disaster Declaration'* areas and made eligible for individual and / or public government assistance. Katrina disaster areas encompassed the state of Louisiana, the state of Mississippi, 22 counties in the West of Alabama and 11 counties in western and southern Florida.[4]

2.1 Financial Institutions' Market Shares

I use the year 2000's cross section of the Home Mortgage Disclosure Act (HMDA) Data to compute the market shares of each mortgage lender in each Core Based Statistical Area (CBSA)[5] and each county in the U.S. HMDA provides loan application-level information on the location of the property in question, the amount of the requested loan, decisions made by lenders regarding applications, regulatory information about lenders, demographic and income information about applicants. Using the information provided on the loan amount and the origination / denial decision for all lenders and loans covered by HMDA, I compute the market share of each lender i in each CBSA or county j as

[3]By analogy, the international transmission of credit market fluctuations through global banks' ICMs led some countries to adopt protectionist measures, such as *'ring-fencing'*, to limit the penetration of international banking activities in domestic markets [Goldberg and Gupta 2013].

[4]This includes four FEMA disasters: Disaster 1602 for Florida declared in 8/28/2005, Disaster 1603 for Louisiana declared in 8/29/2005, Disaster 1604 for Mississippi declared in 8/29/2005 and Disaster 1605 for Alabama in 8/29/2005. Consequently these regions were made eligible for public and / or individual Federal assistance. A map of these FEMA disaster declarations is provided in Appendix Figure A1. In Appendix Figure A2, I provide an overview of the extent of the damage in these areas.

[5]Core-Based Statistical Areas (CBSAs) are either micro or metropolitan statistical areas. This notion refers to a set of counties clustered around one core of at least 10,000 population. The criteria of clustering these counties together into CBSAs is the level of social and economic integration with a common core measured through commuting ties.

follows:[6]

$$W_{ij} = \frac{Lending\ by\ Institution_i\ in\ CBSA_j\ or\ County_j}{Total\ Mortgage\ Lending\ in\ CBSA_j\ or\ County_j} \tag{1}$$

2.2 Historic Market Presence (Lenders' Geographic Footprint) in Katrina areas

Second, for each mortgage lender i, I compute a measure of its historic market presence in Katrina-hit regions (Geographic footprint), defined as the ratio of loans originated or purchased in Katrina-hit counties to the total mortgage lending of the institution in year 2000 defined as:

$$PExp_i = \frac{Lending\ by\ Institution_i\ in\ Katrina\ Areas}{Total\ Mortgage\ Lending\ by\ Institution_i} \tag{2}$$

The sample of mortgage lenders at hand includes 7458 mortgage lenders in year 2000. Table (1) provides summary statistics for the total mortgage lending portfolio of these institutions and two measures of geographic diversification: the number of CBSAs and counties an institution operates in. Among these lenders, 1,358 had some geographic footprint in Katrina areas. In 2000, the median lender operated in 5 CBSAs or 9 counties, had a yearly mortgage lending volume of about $10 million and no footprint in Katrina areas. However, the distribution is skewed to the right with the average lender operating in 29 CBSAs or 67 counties, with a yearly mortgage lending of about $163 million and 4.8 % of its loans originated in Katrina areas. Accordingly, lenders with market presence in Katrina areas were, on average, larger institutions with more geographically diversified loan portfolios.

[Table (1) about here]

2.3 Geographic Financial Inter-linkages

Financial linkages between undamaged CBSA (county) j to Katrina-hit areas are given by sum of the Katrina footprint of each one of the N mortgage lenders serving CBSA (county) j weighted by their

[6] I include originations and loan purchases in this definition.

respective market shares in the CBSA's (county) local mortgage market:

$$Link_j = \sum_{i=1}^{N} W_{ij} \times PExp_i \tag{3}$$

This measure of inter-linkages is calculated using HMDA data for all CBSAs and urban counties in the U.S. It measures the extent to which a region is financially connected to Katrina-hit regions via common mortgage finance institutions. I compute it for all undamaged CBSA's and counties using the HMDA 2000's cross-section. High values of the index $Link_j$ indicate that significantly important financially institutions in $CBSA_j$ $(county_j)$ also have significant geographic footprint in Katrina-damaged regions. Low value of $Link_j$ corresponds to a local mortgage mortgage market in which financial institutions had negligible market presence in Katrina areas. The map in Figure 2 illustrates the relative strength of financial ties to Katrina-hit areas of all urban counties, after the removal of Katrina-hit states and the four adjacent states (Arkansas, Georgia, Tennessee and Texas).

[Figure 2 about here]

Due to the near universal coverage of HMDA encompassing about 90% of mortgage activities in the U.S. [Dell'Arricia et al. (2012)],[7] these measures of market share, geographic footprint and financial linkages provide an accurate picture of mortgage finance networks in the U.S.

2.4 Contribution of different types of institutions to Financial linkages

To identify the types of financial institutions that are responsible for these linkages, I decompose the financial connectedness measure introduced in equation (3) to an aggregation of linkages via the different types of HMDA-reporting institutions.[8] Accordingly, equation (3) can be re-written as fol-

[7]HMDA reporting is governed by Regulation C and covers: 1) All depository institutions whose total assets exceed an asset threshold ($45 million in 2018), have at least one branch in a Metropolitan Statistical Area MSA, originated a minimum number of loans and 2) All Non-Depository institutions whose total assets exceed a threshold ($10 million in 2018), have a branch office in an MSA and originated a minimum number of loans.

[8]Based on the regulator reported, HMDA data allows to distinguish between six types of financial institutions: National Banks regulated by the Office of the Comptroller of the Currency (OCC), State-Chartered

lows:[9]

$$Link_j = \sum_{k=1}^{K} \sum_{i=1}^{N_k} W_{ikj} \times PExp_{ik} \tag{4}$$

Where N_k is the number of mortgage finance institutions i's serving CBSA or county j and regulated by agency k. The financial connectedness of an area j to Katrina-hit regions is the sum of its connectedness via national banks, state banks, thrifts, credit unions and mortgage companies. I compute and report in Table (2) each of these components for the universe of counties outside of Katrina-hit regions and their adjacent states; that is after dropping the counties located in Louisiana, Mississippi, Florida, Alabama, Georgia, Tennessee, Arkansas and Texas. Consistent with Landier el al. (2017), I show that financial institutions of national scope, mainly national banks NBs and mortgage companies MCs, have higher contributions to geographic financial linkages. Conversely, due to their more localized lending activities, state banks, credit unions and thrifts have much smaller contributions to these linkages. Together, NBs and MCs are responsible for about 70% of these inter-linkages.

[Table 2 about here]

2.5 Data on Banks' Mortgage and Financial Activities:

Regarding Banks' mortgage activities, I use cross-sections of HMDA data to form a panel spanning the period 2001-2009. Based on the loan level information provided by HMDA, I compute banks' mortgage loan approval rates in each local market at each year, their likelihood of entry and lending volumes in different local markets. To provide a more comprehensive picture of the banks studied, I

Banks that are members of the Federal Reserve System, State-Chartered Banks that are not members of the Federal Reserve System regulated by the Federal Deposit Insurance Corporation (FDIC), Thrifts supervised by the Office of Thrift Supervision (OTS), Credit Unions regulated by the National Credit Union Administration (NCUA) and Non-depository mortgage companies regulated by the Department of Housing and Urban Development (HUD).

[9]Under the US dual banking system, two different regulatory structures co-exist for commercial banks. National banks are federally regulated by the OCC while state banks are state-chartered and regulated by state-level regulators. While national banks must be members of the Federal Reserve System, state-chartered banks may join if they meet certain requirements. On the other hand, mortgage companies are non-depository financial institutions and are regulated by the Department of Housing and Urban Development.

link banks' mortgage activities to their financial statements from the end-of-year Quarterly Reports of Condition and Income (Call Reports) maintained by the Federal Reserve Bank of Chicago.

2.6 Other Housing, Credit and Local Labor Markets Data Sources:

I use quarterly CBSA-level and yearly county-level Housing Price Indices made available by the Federal Housing Finance Agency (FHFA). The FHFA HPI measures the movement of single-family house prices, based on repeated sales or refinancing transaction on same properties, whose mortgages were purchased or securitized by Fannie Mae or Freddie Mac, at multiple points of time.

To measure residential development activities, I compile data from the Building Permits Survey (BPS) maintained by the US Census Bureau. The BPS aggregates, at the county-year level, data from individual permits forms (Form C-404) including information on the number of buildings and housing units authorized, in addition to the monetary valuation of the construction. I also use annual county-level estimates of the housing stock, measured as the number of housing units, provided by the Census Bureau. To proxy for housing supply elasticity at the county level, I use disaggregated land unavailability measures computed by Lutz and Sand (2017) as the percentage of land unavailable for development due to topographic factors.

Using HMDA Loan Application Register data, I compute several measures of mortgage market activity at the county level, including average county-year level loan approval rates, yearly count of loan applications per county and total yearly mortgage lending per county. I also use interest rate data at the state level and for a set of large metropolitan areas from the FHFA interest rate survey. Finally, I collect local labor market data including, civilian labor force, employment and unemployment, from the Local Area Unemployment Statistics (LAUS) maintained by the Bureau of Labor Statistics.

3 Link 1: Abnormal Housing and Credit Market activities in the Katrina-hit areas

I verify the first link in the causal chain by testing the hypothesis about the emergence of abnormal housing and mortgage markets' activities in Katrina-hit regions, consistent with a reconstruction boom fuelled by disaster aid and insurance payments.[10] In a simple IS-LM-AS-AD framework, this could be illustrated as a rightward shift to the IS curve, reflecting a positive shock to aggregate demand, leading to a a stronger demand for credit, an expansion of output and a higher price level.[11] I use the following specification to test these predictions by documenting the change in local housing and mortgage markets' activities in disaster areas, compared to neighboring non-disaster areas around the timing of Katrina:

$$Activity_{it} = \alpha + \eta_i + \zeta_t + \sum_{\tau \neq 2004} \mathbb{1}[\tau = t] \times Disaster_i \times \mu_\tau + \epsilon_{it} \tag{5}$$

$Activity_{it}$ is a measure of housing or credit market activity in county i at year t. The effects predicted by a simple IS-LM-AS-AD framework can be proxied by building permits issuance, the growth of the housing stock (output expansion), home values (price level) and mortgage lending growth. Additionally, to illustrate the average response of banks' loan supply in disaster areas, I use the average county-year level loan application approval rate as a dependent variable. η_i and ζ_t denote county and year fixed effects respectively. $\mathbb{1}[\tau = t]$ are a set of indicator functions equalling one at their corresponding years and zero otherwise. $Disaster_i$ is a time-invariant dummy that equals one if county i

[10] Reconstruction & local demand were plausibly fuelled by several government programs. These include, but are not limited to, the National Flood Insurance Program, low interest rate disaster loans from the Small Business Administration, as well as the Department of Housing & Urban Development Community Development Block Grants. See Gallagher & Hartley (2017) for a comprehensive discussion of different disaster aid programs deployed in the aftermath of Katrina.

[11] While there were significant migration flows out of disaster areas, the reduction in the housing stock exceeded the reduction in population causing a net positive housing demand shock in disaster areas. This led to a significant surge in housing prices after the storm. Construction boomed in the disaster areas to meet the abnormal demand on housing in the aftermath of the storm [Vigdor 2008].

was declared a disaster area by one of the four FEMA major disaster declarations related to Katrina and zero otherwise. For the purpose of this test, I limit the areas considered to the set of counties in the four states that were fully or partially impacted by hurricane Katrina including Alabama, Florida, Louisiana and Mississippi. Accordingly, treatment counties include 179 counties that were included by Katrina-related disaster declarations. Control counties include the set of counties in Alabama and Florida that were not declared disaster areas. These areas include Eastern Alabama, Central Florida and most of North Florida.[12] The coefficients of interest are the pattern on the μ_τ's that capture the difference in activity measures between disaster and non-disaster counties in each year, relative to an omitted category (the average difference between these two sets of counties in the year before the hurricane 2004) normalized to be zero.

Plots of regression estimates μ_τ's shown, in Figures 3 and 4, point to zero or constant difference between various market activity indicators in the treatment and control groups prior to the hurricane, implying superimposed or parallel trends. Consistent with Cortés & Strahan (2017) and Vigdor (2008), the estimates point to a booming demand for housing and mortgages in disaster areas, starting exactly after the hurricane, relative to the neighboring undamaged counties. This includes a sharp surge in residential development (building permits issuance), faster growth of the housing stock, faster increases in mortgage loans' applications and faster growth of total lending volumes.

I also document a significant surge in mortgage loan application approval rates in disaster areas, relative to the neighboring undamaged counties, consistent with a significant flow of capital towards disaster areas in the aftermath of the hurricane.[13] This abnormal market activity did not dissipate swiftly. Different housing and mortgage market indicators in the damaged areas remained abnormally

[12]While I use parts of Alabama & Florida as the control group, the same pattern of results holds for different control groups such as the set of undamaged counties in the U.S. South and Non-Southern counties. For different choices of the control group, construction and mortgage lending activities indicate a significant demand boom in disaster areas in the post storm period.

[13]This observation is also consistent with Cortés & Strahan (2017)'s argument about regulators urging financial institutions to increase credit availability in disaster areas.

high relative to their pre-storm levels and to the control group, for at least five years after the storm, consistent with the long-term reconstruction process in Katrina-damaged areas. In fact, after more than ten years after Katrina, some of the mostly damaged areas didn't reach their pre-Katrina population and housing stock levels.[14]

[Figures 3 and 4 about here]

4 Link 2: Within-Banks Resource Re-allocation and Banks' *'Winner-Picking'* Strategy

4.1 Capital Flows Towards Disaster Regions

I verify the second link in the causal chain by showing that booming disaster areas, attracted banks' capital away from the undamaged ones. To demonstrate this link, I start by showing that multi-market banks, headquartered outside of the American South,[15] [16] were more likely to enter local markets in disaster regions compared to entering undamaged markets in the post Katrina period, consistent with a flow of capital towards disaster areas. To empirically document this statement, I estimate the following linear probability model:

$$Market\ Entry_{ict} = \alpha + \eta_{ic} + \gamma_{it} + \sum_{\tau \neq 2004} \mathbb{1}[\tau = t] \times Katrina_c \times \mu_\tau + \epsilon_{ict} \tag{6}$$

$Market\ Entry_{ict}$ is a binary indicator that equals one if bank i originated at least one loan in

[14] https://www.census.gov/newsroom/blogs/random-samplings/2016/05/after-hurricane-katrina-where-are-they-now.html

[15] I use the U.S. Census Bureau wide definition of the South, as the region including: Delaware, the District of Columbia, Florida, Georgia, Maryland, North Carolina, South Carolina, Virginia, West Virginia, Alabama, Kentucky, Mississippi, Tennessee, Arkansas, Louisiana, Oklahoma and Texas. I use the address reported in HMDA Transmittal Sheets as the address of banks' headquarters. Being headquartered that far, these banks are plausibly otherwise unaffected by the storm.

[16] Similar to Gilje et al. (2016), this analysis is restricted to banking institutions including OCC-regulated national banks, state banks reporting the Federal Reserve as their main regulator and state banks reporting the FDIC as their main regulator.

CBSA c at year t and zero otherwise, conditional on having received at least one application in year t regarding a property in CBSA c. Accordingly, $Market\ Entry_{ict}$ measures banks' entry / exit decisions to different local markets at the extensive margin.[17] $Katrina_c$ is a time-invariant dummy variable that equals one for CBSAs located in Louisiana or Mississippi, and zero otherwise. $\mathbb{1}[\tau = t]$ is a set of indicator functions equaling one at their corresponding year and zero otherwise. The specification at hand holds all bank-level characteristics γ_{it} constant including their time-varying component. Bank-CBSA η_{ic} are also held constant to capture factors related to banks' location-specific financial policy, including average market presence and unobserved preferences for investing in different local markets. The coefficients of interest μ_τ's quantify the average difference in the likelihood of banks' entry to local markets in Louisiana or Mississippi compared to their likelihood of entry to local markets in the undamaged areas, relative to an omitted category μ_{2004} normalized to be zero.

As shown in figure 5, the estimated coefficients μ_τ's demonstrate a positive shift in the average likelihood of banks' entry to disaster areas, compared to their likelihood of entry to other markets. This flow of capital towards disaster areas coincided exactly with the timing of the hurricane in 2005. Since the specification holds all bank time-varying characteristics constant including total supply of mortgage lending, the estimated μ_τ's indicates a relative substitution between markets within a bank's yearly portfolio of originated loans. Considering the period of study 2001:2009, I report, in column (1) of table 3, a 4.25 percentage points average increase in the likelihood of a non-Southern bank entering a local market in Louisiana or Mississippi in the post-Katrina period, relative to the likelihood of the same bank entering undamaged local markets. Consistently, column (2) point to a 31% average increase in the dollar amount of Non-Southern banks' lending in disaster markets compared to their lending in non-disaster markets. Together, estimates plotted in figure 5 and reported in table 3, provide evidence on disaster regions in Louisiana and Mississippi attracting banks' capital away from the rest of the country starting immediately after Katrina. This flow of capital is consistent with a relative

[17] I also use other continuous measures of bank lending volumes and obtain consistent results.

geographic substitution by banks towards disaster areas.

[Figure 5 and Table 3 about here]

4.2 Banks with Prior Geographic Footprint in Katrina-hit Areas

Second, to provide complementary evidence on the re-allocation hypothesis, I show that banks' having historic geographic footprint in Katrina areas, as defined by equation 2, reduced their supply of loans outside of disaster areas in the post-storm period. To avoid potential confounding factors from the labor markets effects of the hurricane, I focus on banks' credit supply decisions in the CBSAs outside of the four storm-hit states, as well as their four adjacent states.[18] I use a three-dimensional panel [Bank-Year-CBSA] to estimate the following specification:

$$CS_{ict} = \alpha + \eta_{ic} + \zeta_{ct} + \sum_{\tau \neq 2004} \mathbb{1}[\tau = t] \times PExp_i \times \mu_\tau + \Gamma X_{it} + \epsilon_{ict} \tag{7}$$

CS_{ict} is a measure of Bank's i credit supply decision in CBSA c at year t. Since banks' loan origination volumes are equilibrium outcomes of supply and demand, attributing changes in origination volumes uniquely to supply side factors is challenging. I deal with this concern as follows. As a credit supply measure, I follow Jiménez et al. (2012), Loutskina and Strahan (2009, 2011) and Antoniades (2016) and use bank i's mortgage loan approval rates at each local market at each year as a supply side measure. The intuition of this approach is that, the approval or denial decision is made conditional on the loan application being already submitted, which plausibly incorporate information about the demand on credit facing each bank in each local market at each year. Second, CBSA-year fixed effects ζ_{ct} account for all time-varying demand side shocks at the CBSA level. Since banks might have different market strategy regarding different local markets, I include η_{ic} denoting bank-CBSA fixed effects

[18] I remove all CBSAs that are fully or partially located in disaster states or their adjacent states. This includes Alabama, Arkansas, Florida, Georgia, Louisiana, Mississippi, Tennessee and Texas.

to capture factors driving the financial policy of banks in each CBSA including the average physical market presence, branches and banks' unobserved preferences for investing in each local market. I also match banks with their respective balance sheet data from the end-of-year Quarterly Report of Condition and Income (Call Reports). I use the Call Reports data to account for main financial variables including total assets, core deposits to asset ratio, interest expenses to assets, non-performing loans to assets, equity ratio, liquidity ratio, unused commitments & provisions for loan loss.[19] I use the lagged version of these variables to form a bank-year vector of lagged financial controls X_{it}. Similar to Gilje et al. (2016) and Antoniades (2016), I focus on bank lenders including national and state banks.[20] $PExp_i$ is the historic market presence (geographic footprint) of bank i in Katrina disaster areas measured using the HMDA loan-level data in year 2000 as defined in equation 2. $\mathbb{1}[\tau = t]$ are a set of indicator functions that equal one at their corresponding years and zero otherwise.

The estimated coefficients μ_τ's quantify the average difference in loan approval rates between banks having different historic market presence in Katrina areas, at each year, relative to an omitted category μ_{2004} normalized to be zero. Based on the estimates provided in Figure 6, I document an abrupt decline in banks' loan approval rates, in non-disaster areas, immediately after the storm. Considering the period of the study 2001:2009, estimates provided in column (1) of Table 4 quantify this decline in approval rate to be, on average, 1.24 percentage points in the post period relative to prior to the storm (the average bank had 4.8% $PExp_i$), consistent with a credit contraction in the undamaged areas that occurred simultaneously with increased capital flows towards disaster areas as shown in figure 5. The trend on the estimates μ_τ's point to a negligible and constant effect of $PExp_i$ on the outcome of interest, loan approval rate, for an extended period of time prior to Katrina.

[Figure 6 and Table 4 about here]

[19] All variables' definitions are provided in the Appendix.

[20] The sample at hand focuses on bank institutions given the availability of their balance sheet data provided by the Call Reports. While currently having high weight in the mortgage market, HUD-regulated mortgage companies have less stringent reporting requirements and less financial data available.

By being more geographically dispersed, larger banks are, on average, more likely to have some market presence in Katrina areas. In fact, the summary statistics in Table 5 indicate that only a minority of 448 banks had, in 2000, some geographic footprint in Katrina areas. However, this minority was responsible for more than two-thirds of bank mortgage lending reported in HMDA.[21] In addition to controlling for size, I conduct a sub-sample analysis based on the disaggregated computation of financial linkages in equation 4 to show that national OCC-regulated banks had a stronger response to this shock compared to state banks [Table 2]. Accordingly, I re-estimate specification 7 separately for the sets of national and state banks. The estimates reported in columns (2) and (3) of Table 4 show a larger response for national banks and insignificant response for the set of state banks, consistent with the fact that national banks are more geographically dispersed compared to the more geographically compact activities of state banks.

4.3 The Economic Trade-off driving Resource Re-allocation

In light of the literature on informational frictions and internal capital markets [Berrospide et al. 2016; Chakraborty et al. 2018; Stein 1997, 1998], banks maximize their profits, by choosing among available projects, subject to some resource constraints; a *'winner-picking'* strategy as framed by Stein (1997). Informational frictions impose constraints on banks' ability to access capital markets and to pursue all available investment opportunities simultaneously leading to the observed geographic substitution [Figures 5 and 6].

Two points help rationalize banks' substitution behavior: the existence of financial constraints limiting banks' access to external capital, and a relatively higher rate of return for projects in disaster areas in the post-Katrina period compared to non-disaster areas. Together, these two factors provide the economic rationale for banks' observed substitution towards disaster areas and away from the

[21] This observation is consistent with Landier et al. (2017) who attribute the increases in house price correlation between states to large and regionally integrated banks operating in multiple states and resulting in a synchronization of lending decisions between different regions.

undamaged regions. I, hereafter, provide evidence supporting the validity of these two points:

4.3.1 Financial Constraints

I conduct sub-sample analyses to show that the banks that were seemingly less financially constrained were less involved in the observed geographic substitution following the shock of Katrina. Liquidity shocks have weaker effect on credit supply decisions of banks with ample deposit funding [Cornett el al. 2011 and Ivashina and Scharfstein 2010]. I stratify the sample around the median values of two measures of the availability of internal funding: banks' core deposits to assets and banks' equity ratios as proxies for banks' financial constraints.[22] I re-estimate specification 6 for the sets of constrained and unconstrained banks where constraints are proxied by these two measures of deposits and equity. Using deposit funding availability, I show insignificant response of the sample of unconstrained banks as opposed to a larger response for the constrained sample. The statistically significant difference between the point estimates for the two sub-samples provided in columns (1) and (2) of Table **??** suggests that deposit funding alleviate banks' financial constraints consistent with Ivashina and Scharfstein (2010). Regarding equity ratio, I show, in columns (3) and (4), that banks with weaker equity funding had a more pronounced re-allocation pattern than the higher equity sample. However, I fail to reject the null hypothesis of the equality of the estimated responses. Accordingly, as opposed to deposit funding, equity funding does not seem to totally alleviate financial constraints in this context.

[Table 6 about here]

The results shown in Table 6 suggest that disaster markets were more preferred than other markets for constrained banks in the post-disaster period. On the other hand, consistent with Chakraborty el al. (2016), unconstrained institutions are less responsive to local shocks.

[22] Core deposits to assets are defined as (Total transaction accounts + Money Market Deposits Accounts MMDA's + Other Non-Transaction Savings Deposits (excluding MMDA's)+ Total time deposits of less than $100,000 - Total Brokered retail deposits issued in denominations of less than $100,000) / Total Assets

4.3.2 Interest Rates Differential Between the Damaged and Undamaged Areas

Second, I document the emergence of a positive interest rate differential between Katrina-damaged areas and the undamaged regions, immediately after the storm. This interest rate differential plausibly provided an incentive for the movement of funds within banks' ICMs towards reconstruction efforts and away from undamaged markets. In addition, this increase in the price of credit is also consistent with the positive aggregated demand shock induced by reconstruction efforts as show in Figures 3 and 4. To test this hypothesis, I collect yearly state-level interest rates on conventional single-family mortgages provided by the interest rate survey of the FHFA. I provide supporting evidence on higher mortgage interest rates in Louisiana and Mississippi, compared to the rest of the country, consistent with higher rates of return attracting capital towards disaster areas and away from the undamaged areas. To empirically document this statement, I estimate the following specification:

$$IR_{st} = \alpha + \eta_s + \zeta_t + \beta_1 \times \mathbb{1}[Year > 2005] \times Katrina_s + \epsilon_{st} \tag{8}$$

IR_{st} is the conventional single family mortgage rate at state s at year t. $Katrina_s$ is a dummy variable that equals one for Louisiana and Mississippi and zero for other states. $\mathbb{1}[Year > 2005]$ is an indicator function that equals one for the post-Katrina period and zero otherwise. η_s denotes state fixed effects and ζ_t are year fixed effects. β_1 quantifies the average difference in mortgage rates between Louisiana and Mississippi and the rest of the country.[23]

Consistent with the abnormal housing and mortgage activities observed in Katrina-damaged regions (Figures 3 and 4). I show, in table 7, that interest rates increased in Louisiana and Mississippi in the post-Katrina period by 0.11 percentage points, on average, relative to the undamaged states.

[Table 7 about here]

[23] Since the data is only provided at the state-year level, I consider disaster states to be only Louisiana and Mississippi.

4.4 Securitization and Banks' Financial Constraints

Were these constraints fully eased by the intervention of the Government-Sponsored Enterprises GSEs or by securitization practices more generally? Securitization can weaken the link between banks' financial conditions and loan supply decisions [Loutskina and Strahan 2009]. It can also alleviate the effect of local economic downturns on regionally diversified banks' credit supply [Loutskina 2011]. However, this excess lending in disaster areas was not fully absorbed by the GSEs or by non-agency securitization. First, consistent with Chakraborty et al. (2016), I show that significant amounts of mortgage lending are retained on balance sheets. Specifically, about 39% of the volume of mortgage originations (dollar amounts) in local markets in Louisiana and Mississippi during 2001-2009 correspond to portfolio lending,[24] compared to a national average of 33%.

[Table 8 about here]

Second, I use the information provided by HMDA data to compute banks' retained origination volumes in each local market. Using specification 6, I show an abnormal increase in the volume of lending originated in Louisiana and Mississippi and retained on banks' balance sheets starting immediately after the storm. Specifically, results in column 3 of table 3 point to a 20% increase in the average volume of banks' funding originated in disaster areas and retained on banks' balance sheets after the storm relative to volumes retained in non-disaster areas. This increase occurred immediately after the storm [Appendix Figure A4]. Together, these two points suggest that disaster lending occupied an increasing space on banks' balance sheets starting 2005 and that securitization did not fully alleviate the constraints arising from post-disaster lending.

[24]Since HMDA data only provides information on loan sales within the calendar year, this measure can be downward biased. However, recent evidence provided by Adelino et al. (2019) suggests that this bias is limited. The vast majority of loans securitized are sold shortly after origination. Specifically, more than 92% of GSE loans and more than 78% of privately securitized loans are sold within two months of origination.

4.5 The Role of Community Banks

Community banks' networks don't span a large number of local markets as they tend to focus on building lending relationships in a small number of local markets. Consequently, they are less likely to have exposure or to respond to geographically distant events such as Katrina. Due to their localized scope of banking activities, community banks are not expected to re-allocate resources between geographically distant areas. While there is no consensus on a clear-cut definition of community banking, a common approach is to use an asset size threshold [FDIC 2012]. I conduct a falsification test by restricting the analysis to banks with less than $BN 1 of assets.[25] Accordingly, I re-estimate specification 6 for smaller-scale community-oriented banks. The results indicate insignificant response to the shock of Katrina for small and geographically limited banks headquartered outside of the South.

[Table 9 about here]

5 Link 3: The Impact of Financial linkages Housing and Credit Markets

The previous findings document credit supply contractions by financially constrained multi-market banks in the undamaged regions in the U.S., driven by their re-allocation of resources towards reconstruction activities in disaster areas. The last hypothesis tested by this paper is that, the undamaged regions witnessed a decline in housing prices in the post-Katrina period, in recognition of this credit supply disruption. An exogenous variation between the undamaged areas emanates from the heterogeneity in their financial linkages to Katrina-hit areas, since banks' optimization was driven by reconstruction activities in the damaged areas and was plausibly unrelated to housing market fundamentals, including demand factors, in the distant undamaged markets. To the extent that credit supply

[25] In addition to small asset size, community banks are also characterized by focusing on the provision of traditional banking services to their local communities, working on limited number of local markets & by their reliance on relationship lending & hands-on experience in their local markets [FDIC 2012]. See the FDIC Community Banking Study (2012) for a comprehensive discussion on community banks and their role within their local economies. https://www.fdic.gov/regulations/resources/cbi/report/cbi-full.pdf.

influence housing markets, housing prices in the areas with strong financial ties to Katrina-hit markets were more responsive to this credit disruption.

I start by exploiting within-state heterogeneity in CBSAs' financial linkages to disaster regions as defined in equation 3. This measure of financial linkages quantifies the extent to which an undamaged CBSA or county is connected, through common financial institutions, to Katrina areas. Accordingly, a region having a high market share of banks linked to Katrina areas is highly financially linked to Katrina regions. Areas primarily served by banks with little or no ties with to disaster areas would be marginally linked to Katrina regions.

I compare HPI trends for CBSAs with different strength of financial linkages to disaster areas, within their respective states. Similar to the previous analyses, I drop the CBSAs located in the four states that were impacted or partially impacted by Katrina and the ones located in the four adjacent states including Arkansas, Georgia, Tennessee and Texas.[26] Since this research design relies on a within-state comparison, I also drop CBSAs that lie within two or more states. Finally, I focus on the CBSAs for which I can retrieve labor market data from the Bureau of Labor Statistics. The sample at hand contains 220 CBSAs in 36 states.[27] The average state in the sample contains 6.1 CBSAs.[28]

5.1 Graphical Analysis

To study the evolution of HPI trends around the timing of Katrina, I compute the distribution of CBSAs' financial linkages to Katrina regions within each state. Hence, I identify the least and most connected quartiles of CBSAs within their respective states. Accordingly, within each state, the least and most financially connected CBSAs serve as treatment and control for each other. A within-state comparison holds all state-wide policies and demand shocks constant. Figure 1 shows the evolution of

[26]In all prices and quantity analyses, I drop these eight states to lessen potential concerns about confounding factors related to local labor markets' impacts of the hurricane.

[27]Some states are excluded at they don't contain more than one CBSA to conduct a within state comprison. These states are Connecticut, the District of Columbia, New Hampshire, Maine, Massachusetts and Vermont.

[28]A list of all CBSAs included in the analysis is provided in the Appendix.

housing price trends of the least and most connected quartiles of CBSAs around the timing of Katrina. The trends of the treatment and control groups support the following observations. First, I do not observe any differential trend between the treatment and control groups of CBSAs prior to the exact timing of the storm (late August 2005). For an extended period of time before Katrina, trends remained superimposed. Second, the divergence of trends occurred exactly after Katrina in the fourth quarter of 2005. Third, the post-Katrina gap in housing prices between the connected and the less connected CBSAs didn't dissipate swiftly. Actually, the gap stopped widening in early 2007 and remained stable afterwards. Finally, this pattern corresponds to the time pattern of banks' credit supply substitution towards the disaster markets shown in Figures 5 and 6 and the reconstruction process in the damaged regions shown in Figures 3 and 4.

5.2 Specification

To formally identify the exact timing of the divergence observed in figure 1, I estimate the following event study specification:

$$ln(HPI_{ist}) - ln(HPI_{ist-1}) = \alpha + \eta_{is} + \zeta_{st} + \sum_{\tau \neq 2004:Q4} \mathbb{1}[\tau = t] \times Link_{is} \times \mu_{\tau} + X_{ist}\Gamma + \epsilon_{ist} \quad (9)$$

HPI_{ist} is the FHFA's house price index of CBSA i in state s at quarter t. The outcome of interest is the first difference of the natural logarithm of HPIs, equivalent to housing prices quarterly growth in each CBSA i at state s at quarter t. This specification accounts for CBSAs' specific levels of home values by first-differencing and for heterogeneous CBSAs' HPI specific trends by accounting for CBSA fixed effects η_{is}. I follow Favara and Imbs (2015) and focus on HPI growth rates for two reasons. First, a housing price index cannot be used to compare price levels across cities, but it can be used to calculate growth rates and to compare prices over time [Himmelberg et al. 2005]. Taking the first difference addresses this concern by controlling for all time-invariant characteristics of different local markets.

Second, housing prices in the United States display heterogeneous trends [Favara & Imbs (2015)]. Accounting for CBSA fixed effects η_{is} controls for CBSA-specific trends in housing price growth. $Link_{is}$ is the measure of financial linkages of the CBSA to Katrina-affected regions as computed using equation 3. X_{ist} are some time-varying CBSA-level controls. $\mathbb{1}[\tau = t]$ are a set of indicator functions that equal one at their corresponding quarters and zero otherwise. Accounting for state-quarters fixed effects ζ_{st} reflects the intuition of the quasi-experiment at hand by using CBSAs, with financial linkages of different strength to Katrina areas, within the same state as treatment and controls for each other. The coefficients of interest are the pattern on the μ_τ's that capture the impact of financial connectedness to Katrina areas at each point of time, relative to an omitted category prior to the hurricane.[29]

5.3 Results

I present the first set of results in Table 10. The estimated coefficients show a set of statistically and economically insignificant μ_τ's prior to the exact timing of Katrina, consistent with the observed parallel trends in Figure 1. For an extended period of time before 2005:Q4, financial connectedness to Katrina areas didn't imply meaningful differences in HPI growth between local markets. Immediately after Katrina, the coefficient $\mu_{2005:Q4}$ points to a one-off negative shock to HPI growth in the CBSAs having strong financial ties to disaster areas, relative to the ones with weak linkages. This transient shock to HPI growth led to a persistent gap in price levels as shown in figure 1, with several post-Katrina coefficients being insignificant.

[Table 10 about here]

The main coefficient of interest is $\mu_{2005:Q4}$. This coefficient estimates the average difference in HPI growth between the CBSAs of different strength of financial linkages, in the quarter immediately following the storm. A coefficient of -0.287 points to lower housing price growth rates, on average by 28.7 percentage points, between CBSAs having a difference of one in the strength of their financial

[29] The omitted category is set as $\mu_{2004:Q4}$, one year prior to the storm. Same pattern holds for other choices.

linkages to Katrina areas. Hence, for the CBSA with the average financial connectedness to Katrina-affected areas (0.025 as shown in Table 8) , the decline in HPI in the fourth quarter of 2005 is 0.71 percentage points. This negative one-off shock to growth rates translated to persistently lower levels of HPI.

6 Addressing potential unobserved heterogeneity between local markets

The identifying assumption in the CBSA-level analysis is that, in the absence of the credit supply disruption induced by Katrina, housing prices would have continued to trend similarly in the connected and less connected CBSAs. Unconfoundedness requires no unobserved factors to be simultaneously associated with both the treatment and the outcome of interest [Imbens & Wooldridge (2009)], home values in this case, conditional on the observed covariates and on the CBSAs being in the same state. While the parallel pre-Katrina trends support the credibility of this assumption, unconfoundedness is not directly testable. However, I observe that the more connected CBSAs have, on average, larger populations [Table 8], consistent with larger markets being more financially integrated in the financial system. I address this challenge using the following series of tests:

6.1 Credit Market Tightening in the Undamaged Regions

Using a sample of yearly data on conventional single family mortgage interest rates in eighteen large metropolitan areas outside of disaster areas and their adjacent states, I provide corroborating evidence on a credit market tightening in the areas with strong financial ties to disaster regions, immediately after Katrina. Specifically, metropolitan areas with strong linkages to Katrina markets witnessed an increase in interest rate compared compared to the weakly linked MSAs, immediately after the storm. This tightening occurred simultaneously with the observed decline in home values observed in figure 1 and supports the hypothesis of a credit-induced decline in home values in the undamaged regions.[30]

6.2 County-Level Analysis

The second test aims at alleviating the concerns about potential unobserved heterogeneity between CBSAs within the same state, using a more granular level of analysis at the county level. I compare the evolution of housing prices of different counties, having different financial linkages to disaster areas, within the same CBSA around the timing of Katrina. This approach accounts for CBSA-time fixed effects and measures the effect of varying financial linkages to Katrina areas between different counties within the same CBSA. Similar to the CBSA-level analysis, I drop all counties located in the states that were partially or fully impacted by the hurricane and their four adjacent states.[31]

Table 12 provides summary statistics of a large series of labor, housing and mortgage markets characteristics averaged during the five pre-Katrina period [2000:2004] for all urban counties outside of Katrina areas and their adjacent states. Summary statistics are presented, in two categories, based on the strength of counties' financial connectedness to Katrina areas. The two subgroups of counties, the highly and weakly linked to Katrina areas, seem to have generally similar average characteristics, including relatively similar labor force and housing market sizes.

[Table 12 about here]

Accordingly, I form a county-year-level panel using the FHFA county-level HPI index to estimate the following difference-in-difference model:[32]

$$ln(HPI_{ict}) - ln(HPI_{ict-1}) = \beta_0 + \beta_1 \times \mathbb{1}[Year > 2005] \times Link_{ic} + X_{ict}\alpha + \eta_{ic} + \zeta_{ct} + \epsilon_{ict} \quad (10)$$

[30]In the online Appendix, I describe this test in greater detail

[31]Similar to the CBSA-level analysis, local markets in Alabama, Arkansas, Florida, Georgia, Louisiana, Mississippi, Tennessee and Texas are dropped from this analysis.

[32]Unlike the quarterly CBSA-level index, the FHFA only provides annual HPI indices for counties.

where HPI_{ict} is the house price index of county i located in CBSA c at year t. The outcome of interest is housing prices' yearly growth in county i in CBSA c at year t. $Link_{ic}$ is the measure of financial connectedness to Katrina areas computed by equation 3 for all counties, using the year 2000's HMDA cross-section. ζ_{ct} are CBSA-year fixed effects that capture all CBSA-wide time-varying demand shocks and policy changes. X_{ict} are some time-varying county-level controls. $\mathbb{1}[Year > 2005]$ is an indicator function that equals one for the post-Katrina period and zero otherwise. Similar to the CBSA-level analysis, this specification accounts for counties' specific levels of HPI by first differencing and for heterogeneous counties' specific trends by accounting for county fixed effects η_{ic}.

The coefficient of interest β_1 quantifies the effect of counties' financial linkages to disaster areas after Katrina relative to the pre-storm period, conditional on counties being in the same CBSA. β_1, reported in Column (1) of table 13, indicates that a unit increase in financial linkages to Katrina-impacted areas resulted in a 36.9 percent decline in housing prices after the storm. Accordingly, the county with the average strength of financial linkages to Katrina-hit areas (0.026 as shown in Table 2), witnessed a decline of 0.96 percent in housing prices in the post-storm period.

[Table 13 about here]

6.3 Timing of the effect and parallel trends (County Level)

To precisely identify the timing of the divergence of trends between the financially linked and less financially linked counties, I compare house prices in different counties within the same CBSA at each point of time using the following diff-in-diff event study specification:

$$\Delta HPI_{ict} = \alpha + \zeta_{ct} + \sum_{\tau \neq 2004} I[\tau = t] \times Link_{ic} \times \mu_\tau + \epsilon_{ict} \tag{11}$$

$I[\tau = t]$ is a set of indicator functions that equal one at their corresponding years and zero otherwise. ζ_{ct} sets the comparison between counties located in the same CBSA. The coefficients of interest are the pattern on the μ_τ's that capture the difference in the change in housing prices between the financially connected and less financially connected counties, relative to the omitted category μ_{2004}.[33]

The μ_τ's estimates, shown in Figure 7, indicate that home values in the financially linked counties started declining exactly at the hurricane year, in 2005, compared to the less financially linked and that the gap significantly increased in 2006, consistent with Katrina's timing in late August 2005. Constant and insignificant estimates of μ_τ's prior to the storm suggest that financial linkages didn't imply meaningful differences in housing prices in the prior to the storm. Similar to the CBSA-level analysis, the parallel pre-storm trends lend support to the unconfoundedness assumption.

[Figure 7 about here]

6.4 Local Banks as Housing Market Stabilizers

I examine the hypothesis that a higher market share of small banks dampened the effect of financial linkages to disaster areas on local housing prices in the undamaged counties. Local banks, outside of the impacted areas, have little financial ties to Katrina markets. By being unexposed to disaster areas, they are expected to insulate their local markets from the external credit shock induced by the storm. I define local banks as the set of lenders reporting the Federal Deposit Insurance Corporation FDIC as their main regulating agency.[34] This definition is based on their geographically compact network of operations and their little contribution to financial linkages between Katrina areas and the undamaged regions as computed in Table 2. I estimate specification 10 with an additional interaction

[33] I also show the same divergence between prices levels in different counties based on their financial connectedness to disaster areas.

[34] State-chartered lenders can be regulated by the Federal Reserve (if members of the FRS) or by the FDIC or by their chartering state. Lenders reporting the FDIC as their regulator have on average much smaller asset size. They work on a limited number of counties and have very little contribution to financial linkages [Table 2]

term including the pre-Katrina share of small scale banks in county i as follows:

$$\begin{aligned} ln(HPI_{ict}) - ln(HPI_{ict-1}) = \alpha + \eta_{ic} + \zeta_{ct} + \beta_1 \times \mathbb{1}[Year > 2005] \times Link_{ics} \\ + \beta_2 \times \mathbb{1}[Year > 2005] \times Link_{ics} \times Share\,Small_{ic} + X_{icst}\Gamma + \epsilon_{ict} \end{aligned} \tag{12}$$

Where $Share\,Small_{ic}$ is the aggregate market share of banks reporting the FDIC as their main regulator computed in 2004 in county i. I show, in column (2) of table 13, that a higher share of local banks dampens the negative effect of the credit shock on housing price growth.[35] Specifically, a 0.01 increase in the fraction of the local market held by local banks reduces the negative effect of the credit shock on local housing prices by 0.01 percentage points.

6.5 Triple Difference and Housing Supply Elasticity

The effect of financial linkages on housing prices in the undamaged regions worked through a credit contraction by banks that re-allocated resources towards disaster areas after Katrina. Similar to Mian & Sufi (2018), credit contractions negatively influence household demand on housing. The magnitude of the effect on local housing prices depends on the elasticity of housing supply. I graphically illustrate the joint equilibrium in the mortgage and housing markets using the following diagram. In the undamaged regions, the Katrina-induced shock led to a mortgage credit tightening, orthogonal to local demand. This tightening shifted the credit supply curve leftward, leading to lower credit availability and higher equilibrium interest rates in undamaged areas. This contraction negatively impacted consumers' demand on housing, leading to a decline in housing prices as shown in figure 1. A decline in residential development is expected and illustrated on the graph as $\Delta Housing$. This translates to a wedge between supply and demand in housing markets with a lower price to sellers $Price\ Sellers$. The mix of price and quantity adjustments to this credit shock depends on the elasticity of housing supply. Large price declines are expected in inelastic markets. Elastic housing markets weather the

[35] The average market share of banks that report the FDIC as their main regulator is about 12-13%.

shock through quantity adjustments along with price responses. This heterogeneity in expected responses provides an additional layer of heterogeneity to difference-out potential unobserved factors, by having subgroups of different responsiveness to the shock within the treatment and control groups of counties.

Topological factors impose barriers on construction, and are commonly used as proxies for housing supply elasticity. Land unavailability measures were introduced to proxy for housing supply restrictions. The rationale behind them is that, natural factors, including steep slopes, water bodies and wetlands, make construction costly and positively predict home values [Saiz 2010]. Such measures were used as instruments for home values by Chaney et al. (2012), Mian & Sufi (2014) and Chetty et al. (2017). I use a granular county-level measure computed by Lutz & Sand (2017), based on satellite imagery, of the percentage of land unavailable for development due to steep slopes, water bodies and wetlands.[36] Accordingly, I employ the following triple difference specification to leverage this third layer of variation:

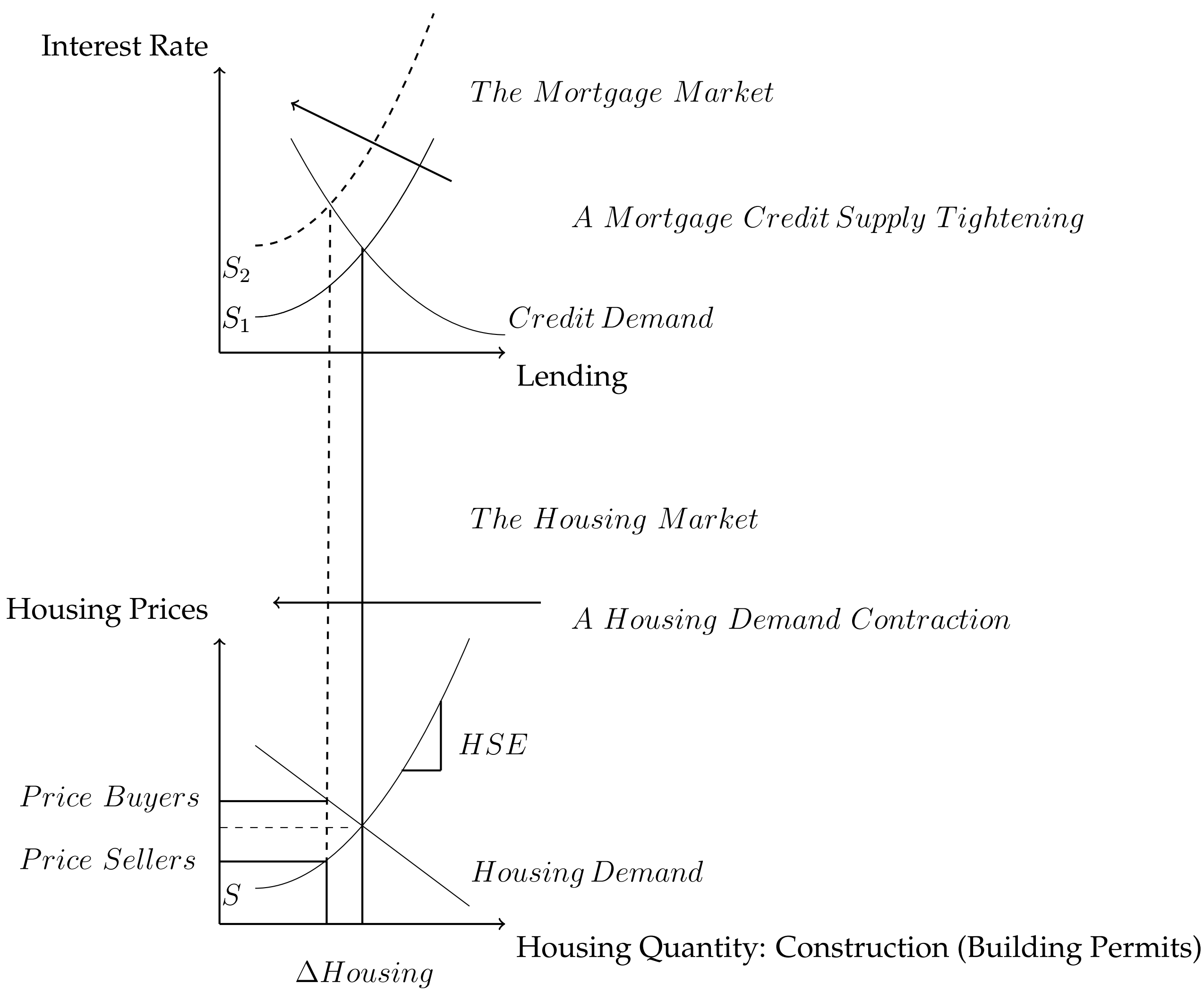
$$Y_{ict} = \alpha + \beta_1 \times \mathbb{1}[Year > 2005] \times HSE_{ic} + \beta_2 \times \mathbb{1}[Year > 2005] \times Link_{ic}$$
$$+\beta_3 \times \mathbb{1}[Year > 2005] \times Link_{ic} \times HSE_{ic} + X_{ict}\Gamma + \eta_{ic} + \zeta_{ct} + \epsilon_{ict} \tag{13}$$

Y_{ict} denotes housing price growth in county i located in CBSA c at year t. X_{ict} are some time-varying county-level controls. $Link_{ic}$ is the measure of financial linkages of county i to Katrina areas. HSE_{ic} is computed using land unavailability measures provided by Lutz & Sand (2017) for county i located in CBSA c.[37] 1[Year>2005] is an indicator function equaling one for the post-Katrina period and zero otherwise. ζ_{ct} are CBSA-year fixed effects capturing CBSA-wide time-varying demand shocks and policy changes and η_{ic} denotes county fixed effects. The triple difference estimator nets-

[36] Measures provided by Saiz (2010) are at the Metropolitan Statistical Area level. I use Lutz & Sand (2017)'s measures given their suitability to the county-year level triple difference framework conducted in this section.

[37] Similar to Favara & Imbs (2015), I compute HSE_{ic} as the inverse of the land unavailability measure.

Joint Equilibrium in Local Mortgage and Housing Markets



<u>A Credit-Induced Housing Demand Contraction</u>: The diagram illustrates the joint equilibrium in the mortgage and housing markets. The upper figure illustrates the partial equilibrium in the mortgage market. The lower figure is the equilibrium in the housing market. Credit tightening acts as a tax driving a wedge between housing supply and demand leading to lower prices to sellers $Price\ Sellers$ and a lower quantities of housing supplied. The size of the effect depends on housing supply elasticity HSE.

out potential unobserved factors that might be confounded with financial linkages to disaster areas. The causal effects are estimated by both β_2 and β_3,[38] where β_2 is the average differential change in the outcome of interest after and before Katrina for the highly inelastic housing markets (HSE_{ic}=0 or no land available).

$$\begin{aligned}\beta_2 = (E[Y_{it}|Inelastic, Linked, Post] - E[Y_{it}|Inelastic, Linked, Pre])\\ -(E[Y_{it}|Inelastic, Unlinked, Post] - E[Y_{it}|Inelastic, Unlinked, Pre])\end{aligned} \tag{14}$$

β_3 is the difference in the causal effect for the counties with high elasticity of housing supply relative to the ones with low elasticity.

$$\begin{aligned}\beta_3 = \overbrace{(E[Y_{it}|Elastic, Linked, Post] - E[Y_{it}|Elastic, Linked, Pre])}^{\beta_3+\beta_2+\beta_1}\\ -\overbrace{(E[Y_{it}|Inelastic, Linked, Post] - E[Y_{it}|Inelastic, Linked, Pre])}^{\beta_2}\\ -\overbrace{(E[Y_{it}|Elastic, Unlinked, Post] - E[Y_{it}|Elastic, Unlinked, Pre])}^{\beta_1}\\ -\overbrace{(E[Y_{it}|Inelastic, Unlinked, Post] - E[Y_{it}|Inelastic, Unlinked, Pre])}^{0}\end{aligned} \tag{15}$$

Since inelastic local housing markets are expected to witness the highest depreciation in home values, β_2 is negative and β_3 is positive, indicating that supply elasticity dampens the negative effect of the shock on housing prices. Based on the estimates of β_2 and β_3 provided in column (3) of table 13, I compute the average treatment effect as follows:

$$ATE = (\hat{\beta}_2 + \hat{\beta}_3 \times \overline{HSE_{ic}}) \times \overline{Link_{ic}} = (-0.408 + 0.372 \times 0.1336) \times .0248 \approx -0.89\% \tag{16}$$

Accordingly, I report a decline in housing prices of %0.89 relative to pre-storm prices for the county

[38]For simplicity of the notation, I assume $Linked_{ic}$ and HSE_{ic} to be binary treatments: Exposed versus Unexposed and Elastic versus Inelastic in Post versus Pre-Katrina period

with the average financial linkages to disaster areas and average housing supply elasticity; a very similar estimate to the one obtained using the previous diff-in-diff analysis in specification 10.

6.6 The response in terms of housing quantities

To document the quantity response of local housing markets, I compile data from the Building Permits Survey (BPS) maintained by the US Census Bureau. The BPS aggregates, at the county-year level, data from individual permits forms (Form C-404) and provides information on the number of buildings and housing units authorized and the monetary valuation of the construction. Using this data, I estimate the following specification:

$$\begin{aligned}\Delta Q_{ict} = \alpha + \beta_1 \times \mathbb{1}[Year > 2005] \times HSE_{ic} + \beta_2 \times \mathbb{1}[Year > 2005] \times Link_{ic} \\ + \beta_3 \times \mathbb{1}[Year > 2005] \times Link_{ic} \times HSE_{ic} + X_{ict}\Gamma + \zeta_{ct} + \epsilon_{ict}\end{aligned} \tag{17}$$

Q is the number of annually issued building permits corresponding to housing units or residential buildings[39] or the monetary valuation of the structures aggregated at the county-year level. β_2 is the effect for highly inelastic markets, β_3 is the additional effect for counties with some positive HSE_{ic} and the Average Treatment Effect ATE is given by: $ATE = (\beta_2 + \beta_3 \times \overline{HSE_{ic}}) \times \overline{Link_{ic}}$. Table 14 shows that β_2 is insignificant for the three measures of quantities suggesting insignificant quantity response in highly inelastic areas. β_3 is negative, economically and statistically significant for the three measures. The estimate of β_3 indicates a post-hurricane decline in the total yearly valuation of construction activities of Mn \$ 7.93 corresponding to forgone projects related to 47.9 housing units and a 30.92 buildings in the county with the average housing supply elasticity and the average financial linkages to Katrina-hit areas. Accordingly, an average of approximately 4.2% of the annual number of housing units supplied at county markets was forgone due to the credit disruption caused by Katrina.

[39] Buildings could correspond to single family or multi-family building (and thus including multiple units)

[Table 14 about here]

7 Conclusions

Economic conditions in a local market influence banks' lending decisions in other areas, and in turn, disrupt housing markets in these areas, by drawing resources away from them. Regarding Katrina, two factors were at the origin of this disruption: fiscal policies that boosted demand for reconstruction in disaster areas and financial constraints that required banks to pick the most profitable projects, leading to a resource re-allocation towards disaster areas and away from the undamaged ones.

I documented three plausibly linked hypotheses forming a coherent causal chain of events. First, I provided evidence on a long-term housing and mortgage boom that emerged in storm-damaged areas immediately after Katrina. Second, responding to this abnormal demand led financially constrained multi-market banks to re-allocate resources towards disaster areas, at the expense of distant undamaged regions. Third, this re-allocation led to a credit tightening, a decline in housing prices and construction in the undamaged areas, starting immediately after Katrina. Local housing markets varied in their response to the shock based on the slope of the housing supply curve. Elastic markets weathered the shock through a mix of housing price and quantity adjustments. Inelastic markets responded primarily with price declines. The average treatment effects points to a 0.89% decline in home values. The estimated quantity response points to 31 buildings or 48 housing units' projects forgone due to the Katrina-related credit shock in the county with the average supply elasticity and average strength of financial linkages to Katrina regions.

Three policy and banking strategy issues are highlighted. First, local funding shocks propagate, through banks' internal capital markets, consistent with Gilje et al. (2016), Cetorelli and Goldberg (2012), Peek and Rosengren (1997) and Hale et al. (2020). Consequently, policies aiming to support some regional housing markets, such as disaster aid, can disrupt housing markets in other regions. Second, by being unexposed to the shock of Katrina, and due to their localized lending activities, local lenders partially shielded their local markets from this external shock. This result highlights the stabilizing role of community banks for local housing markets, specifically vis-à-vis external shocks. Third, reconstruction efforts in the aftermath of natural disasters provide profitable opportunities for banks. Banks strategically and swiftly re-allocated part of their business to disaster areas.

These results have implications beyond the scope of the analysis of the event of Katrina. Local funding shocks could result from a variety of sources including extreme weather events, the development of natural resources or other regional economic fluctuations. This paper adds to the literature on internal capital markets by exploring a new source of funding shocks, that is environmental shocks. Consistent with Gilje et al. (2016), these results also confirm the limitations of securitization in alleviating banks' financial constraints. Consequently, location-specific risks still matter in banks' geographic resource allocation decisions. Most importantly, this paper took a step further by documenting significant real market impacts of these spillovers.

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9 Tables and Figures

Table 1: **Lenders' Size and Regional Diversification for different categories of geographic footprint in Katrina regions**

All Lenders	Obs.	Mean	Std. Dev.	Median
Geographic footprint	7458	0.048	0.195	0
Total Lending of Institution ($1000)	7427	163426.8	1503402	10104
Number of Counties per institution	7458	67.52	280.2	9
Number of CBSAs per institution	7459	29.56	107.32	5
Lenders with No Geographic footprint in Katrina Areas				
Total Lending of Institution ($1000)	6069	31160.54	108868	8129
Number of Counties per institution	6100	15.91	38.62	8
Number of CBSAs per institution	6086	8.01	18.04	4
Lenders with some Geographic footprint in Katrina Areas				
Geographic footprint	1358	0.266	0.39	0.032
Total Lending of Institution ($1000)	1358	754534.4	3447873	44046.5
Number of Counties per institution	1358	299.32	599.15	42
Number of CBSAs per institution	1359	126.25	224.4	21

Note: This table reports summary statistics of financial institutions' historic market presence (Geographic footprint) in Katrina-hit areas computed using the 2000's cross section of HMDA data. The sample is divided based on portfolio exposure to Katrina areas. Other lender-related characteristics are total mortgage lending, in addition to two measure of geographic diversification including the number of CBSAs and counties in which a lender operates.

Table 2: **Undamaged Local Markets' (Counties) Financial linkages to Katrina areas, de-composed & ordered by the type of institutions contributing to financial ties. National Banks & Mortgage Companies have the most contribution to financial inter-linkages.**

Financial linkages to Katrina Areas	Ranking	Mean	Std. Dev.
Total		.026	.01
Through OCC Banks	1	.01	.009
Through HUD Lenders	2	.007	.003
Through Thrifts	3	.004	.003
Through FRS Banks	4	.003	.002
Through FDIC Banks	5	.001	.002
Through Credit Unions	6	.0001	.0002

Note: This table reports summary statistics of undamaged counties' financial linkages to Katrina-hit areas computed, by equation 3, using HMDA data for year 2000. Financial linkages are disaggregated to linkages through different types of financial institutions including national banks, FRS-regulated state banks, FDIC-regulated state banks, Thrifts, Credit Unions and HUD-regulated mortgage companies. Financial institutions are ranked based on their contributions to geographic financial ties. The most geographically diversified and dispersed lenders, including OCC-regulated banks and HUD-regulated mortgage companies, have the highest contribution to financial linkages between local markets. State banks non-members of the FRS & credit unions make much smaller contributions to these linkages with their more localized lending activities.

Table 3: **Post-Katrina Banks' Capital Flow Towards Disaster Areas**

	(1) Market Entry Decision	(2) Total Lending	(3) Retained Lending
$1[\text{Year}>2005] \times \mathbb{1}[Disaster\ Area]$	0.0425***	0.312***	0.202***
	(0.0126)	(0.0370)	(0.0383)
Bank-CBSA FE	✓	✓	✓
Bank-Year FE	✓	✓	✓
Bank-Year groups	20592	20592	20592
Bank-CBSA groups	84792	84792	84792
Number of Banks	3661	3661	3661
Number of CBSAs	929	929	929
Bank-Year-CBSA Observations	356,047	356,047	356,047
R-squared	0.636	0.863	0.851

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Note: This table reports the coefficient estimates for the simple diff-in-diff version of specification 6. The period of study is 2001:2009. Outcome variables include the market entry decision (originating at least one loan) of a given bank at a given year in a given CBSA, the natural logarithm of Bank's i lending amount at CBSA c at year t (log (Lending +10k)) and the natural logarithm of Bank's i retained lending amount at CBSA c at year t (log (Lending +10k)). After Katrina, the estimates indicate an increased likelihood of banks' market entry to Katrina-hit markets in Louisiana and Mississippi compared to entry to other markets in the U.S. (Column (1)), an increase in banks' lending volumes (Column (2)) and an increase in lending originated and retained in disaster areas (Column (3)), consistent with a significant flow of capital towards disaster areas and away from the undamaged areas as shown in figure 5. All banks considered are headquartered outside of the U.S. South (using the Census Bureau definition of the 17 Southern States). Standard Errors are clustered at the CBSA level.

Table 4: **Decline in Loan Approval Rates, immediately after the hurricane, in the Undamaged Regions for Banks' with historic market Presence (Geographic Footprint) in Katrina-affected regions**

	Bank's Loan Approval Rate		
	(1) All Banks	(2) National Banks	(3) State Banks
1[Year>2005] $\times Bank's\, Historic\, Katrina\, Presence$	-0.259*	-0.346**	-0.0239
	(0.156)	(0.165)	(0.0668)
Banks' Balance Sheet Controls	✓	✓	✓
Bank-CBSA FE	✓	✓	✓
CBSA-Year FE	✓	✓	✓
Bank-CBSA groups	49001	23953	25029
Number of Banks	2633	643	1992
Number of CBSAs	690	684	689
Bank-Year-CBSA Observations	222,067	110,120	111,814
R-squared	0.582	0.594	0.581

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Note: This table reports the coefficient estimates for specification 7. The dependent variable is the bank loan approval rate in each CBSA at each point of time in each of the undamaged areas (CBSAs located in Alabama, Arkansas, Florida, Georgia, Louisiana, Mississippi, Tennessee & Texas are dropped from the sample). The explanatory variable is an interaction of post-Katrina period and banks' historic market presence (Geographic footprint) in Katrina-hit areas. The exposure measure is computed, as defined in equation 2 using the HMDA cross-section for year 2000. Balance sheet controls include lagged versions of the natural logarithm of total assets, core deposits to asset size, interest expenses to assets, non-performing loans to assets, equity ratio, liquidity ratio, unused commitments & provisions for loan loss to assets. Column (1) provides the results for the whole sample. Column (2) provides the results for national banks while (3) provides the results for state banks. Trends are superimposed for an extended period of time prior to the hurricane. Standard errors are clustered at the bank level.

Table 5: **Summary Statistics of Banks' Financial Characteristics stratified based on their Historic Market Presence in Katrina Areas**

	Katrina Footprint=0		Katrina Footprint>0	
	Mean	St. Dev.	Mean	St. Dev.
Balance Sheet Variables				
Log assets	12.062	1.095	13.18	1.923
Core deposits / assets	0.702	0.112	0.645	0.134
Interest expenses / assets	0.034	0.007	0.036	0.008
Non-performing loans / assets	0.005	0.007	0.006	0.007
Equity ratio	0.048	0.035	0.047	0.041
Liquidity ratio	0.312	0.131	0.295	0.136
Unused commitments / assets	0.147	1.679	0.176	0.377
Provisions for loan loss / assets	0.002	0.005	0.004	0.009
Number of Banks	2,898		448	
All Originations by each set in 2000	70.2 BN		139 BN	

Note: This table reports summary statistics of different banks' financial variables. Balance sheet variables are extracted from the year-end call report at the start of the period of the study in 2000. The sample is stratified into two categories based on whether banks had some historic geographic footprint in disaster areas.

Table 6: **Weaker or Insignificant Estimated Responses for Financially Unconstrained Sub-samples of banks**

	Market Entry Decision			
Sample Stratified by:	Core Deposits to Assets		Equity Ratio	
	(1) (Constrained)	(2) (Unconstrained)	(3) (Constrained)	(4) (Unconstrained)
$1[\text{Year}>2005] \times \mathbb{1}[Disaster\ Area]$	0.0606***	-0.0158	0.0515***	0.0267**
	(0.0135)	(0.0196)	(0.0177)	(0.0129)
$\text{H}_0 : (\beta_{Constrained} = \beta_{Unconstrained})$	Reject ($\text{z}_{score} = 3.21$)		Fail to Reject ($\text{z}_{score} = 1.13$)	
Bank-Year FE	✓	✓	✓	✓
Bank-CBSA FE	✓	✓	✓	✓
Bank-Year-CBSA Observations	168,490	170,207	166,207	165,030
Bank-Year Clusters	4082	15788	9618	9804
Bank-CBSA Cluster	44019	47400	46832	46599
R-squared	0.653	0.658	0.679	0.636

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Note: This table reports the coefficients' estimates of specification 6 for the set of financially unconstrained banks (High deposit funding and highly equity ratio) and constrained banks stratified around the median values in the sample. Hypothesis testing rejects the Null hypothesis of similar responses between banks with high deposit funding compared to the ones with low deposit funding. On the other hand, it fails to reject the Null hypothesis for banks with high equity ratio compared to the ones with low equity ratio. Standard errors are clustered at the CBSA level.

Table 7: **Increase in Interest Rates in Disaster Areas in the Post-Hurricane Period**

	Mortgage Rates (pct. pts.)
1[Year>2005] $\times \mathbb{1}[Louisiana\ or\ Mississippi]$	0.108***
	(0.0398)
Year FE	✓
State FE	✓
State-Year Observations	459
Number of States	51
R-squared	0.980

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Note: The estimate presented at this table quantifies the average contract interest rate difference between Louisiana and Mississippi, and the rest of the country after the storm compared to before the storm. The period of study is 2001:2009. The dependent variable is an average state-year level single family conventional mortgage contract interest rate provided by the FHFA survey of interest rates. The estimate points to a 0.108 percentage points increase in interest rates in disaster areas (Louisiana & Mississippi) in the post-Katrina period compared to the undamaged areas, consistent with a housing and mortgage boom in these areas, after the storm. Standard errors are clustered at the state level.

Table 8: **Loan Retention, Loan Sales to GSEs and Non-Agency Securitization**

	Retained			GSEs			PLS (Non-Agency)		
Category	Mean	Median	Std. dev.	Mean	Median	Std. dev.	Mean	Median	Std. dev.
LA & MS	39.2%	38.6%	9.3%	23.9%	23.1%	7.9%	32.2%	32.4%	9.9%
National Average	32.1%	31%	10.3%	28.9%	27.3%	10.8%	34.6%	34.4%	11.4%

Note: This table provides an overview of the percentage of originated funds retained, sold to GSEs or privately securitized over the period of the study 2001-2009 in local markets (CBSAs) in Louisiana and Mississippi and in all CBSAs in the United States. The Non-Agency loans category includes loans sales labelled in HMDA data as: Private securitization, Loan sold to Commercial bank, savings bank or savings association, Life insurance company, credit union, mortgage bank, or finance company, Affiliate institution or Other type of purchaser.

Table 9: **Insignificant Response for Community Banks**

	Market Entry Decision
1[Year>2005] $\times \mathbb{1}[Disaster\ Area]$	-0.0175
	(0.0233)
Bank-CBSA FE	✓
Bank-Year FE	✓
Bank-CBSA-Year Observations	127,523
R-squared	0.652

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Note: This table reports the coefficient estimate for the simple diff-in-diff version of specification 6 restricted to the set of banks with less than $ 1 BN of assets. The period of study is 2001:2009. The dependent variable is the market entry decision (originating at least one loan) of a given bank at a given year in a given CBSA. All banks considered are headquartered outside of the U.S. South. Standard Errors are clustered at the CBSA level.

Table 10: **The Impact of Financial Inter-linkages on Housing Prices (Different CBSAs in the same State) and the Divergence of Trends exactly after the storm**

	HPI Quarterly Growth	
	μ_τ	SE.
Coefficient on $\mathbb{1}[\tau = t] \times Link_{is}$		
$\mu_{2001} : Q_1$	0.106	(0.121)
$\mu_{2001} : Q_2$	-0.00888	(0.113)
$\mu_{2001} : Q_3$	-0.173	(0.122)
$\mu_{2001} : Q_4$	0.164	(0.111)
$\mu_{2002} : Q_1$	-0.0255	(0.125)
$\mu_{2002} : Q_2$	-0.0428	(0.103)
$\mu_{2002} : Q_3$	0.0275	(0.118)
$\mu_{2002} : Q_4$	0.0623	(0.108)
$\mu_{2003} : Q_1$	-0.0805	(0.0990)
$\mu_{2003} : Q_2$	-0.0218	(0.104)
$\mu_{2003} : Q_3$	0.118	(0.100)
$\mu_{2003} : Q_4$	-0.137	(0.102)
$\mu_{2004} : Q_1$	0.0298	(0.135)
$\mu_{2004} : Q_2$	0.00187	(0.143)
$\mu_{2004} : Q_3$	-0.0935	(0.136)
Omitted Category μ_{2004Q4}	0	0
$\mu_{2005} : Q_1$	-0.149	(0.131)
$\mu_{2005} : Q_2$	0.00226	(0.162)
$\mu_{2005} : Q_3$	0.0833	(0.150)
$\mu_{2005} : Q_4$	-0.287***	(0.0903)
$\mu_{2006} : Q_1$	0.0538	(0.162)
$\mu_{2006} : Q_2$	-0.0756	(0.123)
$\mu_{2006} : Q_3$	-0.0952	(0.123)
$\mu_{2006} : Q_4$	0.00389	(0.162)
$\mu_{2007} : Q_1$	0.311***	(0.0995)
$\mu_{2007} : Q_2$	-0.0524	(0.149)
$\mu_{2007} : Q_3$	-0.162	(0.113)
$\mu_{2007} : Q_4$	-0.143	(0.112)
CBSA Time-varying Controls	✓	
State-Quarter FE	✓	
CBSA FE	✓	
CBSA-Quarter Observations	6,160	
Number of CBSA	220	
R-squared	0.656	

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Note: This table reports coefficients estimates of the event study specified in equation 9. These estimates quantify the difference in housing price growth between CBSAs with different financial ties to disaster areas. CBSAs located in the states hit by the hurricane or their adjacent states are dropped from the sample. Multi-States CBSAs are not considered. The sample at hand contains 220 CBSAs in 36 states. The omitted category is 2004:Q4 (one year prior to the hurricane). Housing prices growth had insignificant differences for an extended period of time before Katrina indicating parallel trends prior to the storm. Significant difference in HPI growth appears exactly after the storm in 2005:Q4. This one-off shock to HPI growth resulted in a persistent gap in price levels as shown in figure 1. The average state in the sample contains 6.1 CBSAs. CBSAs' time-varying Controls include lagged version of employment, unemployment and HPI. Standard errors are clustered at the CBSA level.

Table 11: **CBSAs' Financial Linkages to Katrina-impacted areas and Housing and Labor markets characteristics of CBSAs in two categories based on the strength of their financial linkages to disaster areas**

Panel A

	Mean	Median	St. Dev.
CBSAs financial linkages	0.0246	0.0243	.00758

Panel B

	Below Median linkages			Above Median linkages		
	Mean	Median	St. Dev.	Mean	Median	St. Dev.
HPI Quarterly Growth (%)	0.995	0.956	1.931	0.968	1.011	2.703
Unemployment Rate (%)	5.461	5.2	1.849	6.081	5.45	2.631
Labor Force (1000)	160.335	90.317	201.243	241.307	104.600	333.276

Note: Panel A reports summary statistics of the measure of CBSA's financial linkages to disaster areas as computed by equation 3. Panel B reports summary statistics of housing and labor markets characteristics of CBSAs in two categories stratified based on the strength of their financial linkages to disaster areas. CBSAs located in the states hit by the hurricane and their adjacent states are dropped from the sample. Multi-States CBSAs are not considered. The sample at hand contains 220 CBSAs in 36 states. Source: HMDA, FHFA and Bureau of Labor Statistics' Local Area Unemployment Statistics (LAUS).

Table 12: **Summary Statistics of Labor and Housing Markets Characteristics of different local markets (counties) in two categories based on the strength of their financial linkages to disaster areas**

Sample Stratified by counties' financial linkages to Katrina areas:	Below Median linkages		Above Median linkages	
	Mean	St. Dev.	Mean	St. Dev.
Labor Markets				
Population (1000)	220.262	423.16	201.651	608.186
Labor Force (1000)	114.422	212.237	101.877	300.397
Unemployment Rate (%)	5.002	1.392	5.38	1.594
Per capita income ($1000)	31.411	8.134	28.546	7.710
Housing Markets				
Yearly HPI Growth (%)	4.8	3.5	4.7	4.1
Housing Supply Elasticity	0.14	0.327	0.13	0.446
Housing Stock (units)	90051.94	170393.6	81466.71	218372.9
Yearly Housing Stock Growth (%)	1.6	1.4	1.6	1.3
Yearly Addition to the stock (units)	1047.383	1517.637	1187.394	3077.562
Mortgage Markets				
Market Share of National Banks	0.33	0.11	0.32	0.10
Market Share FRS Banks	0.14	.08	0.16	.08
Market Share of FDIC Banks	0.13	0.11	0.12	0.09
Market Share of HUD-regulated institutions	0.21	0.09	0.24	0.08
County-Year Observations		2966		

Note: This table reports summary statistics of different characteristics of labor, housing and mortgage markets for two sets of counties based on the strength of their financial linkages to Katrina-hit areas: the below median linked areas and the above median ones. Characteristics are averaged over the five years preceding the hurricane 2000:2004. The sample includes all urban counties outside of Katrina-hit areas and their adjacent states. Housing supply elasticity measures are computed as the inverse of the land unavailability measure provided by Lutz and Sand (2017).

Table 13: **The Impact of Financial linkages to disaster areas on Housing Prices in a County-level Analysis and the Stabilizing Role of Small Scale Community Banks**

	(1) HPI Growth	(2) HPI Growth	(3) HPI Growth
$I[Time > 2005] \times Link$	-0.369**	-0.489**	-0.408**
	(0.171)	(0.196)	(0.177)
$I[Time > 2005] \times Link \times HSE$			0.372
			(0.250)
$I[Time > 2005] \times HSE$			-0.0105
			(0.00645)
$I[Time > 2005] \times Link \times Share\ local\ banks$		1.034***	
		(0.392)	
County-Year Controls	✓	✓	✓
CBSA-Year Fixed Effects	✓	✓	✓
County Fixed Effects	✓	✓	✓
County-Year Observations	6,783	6,733	6,765
Number of Counties	764	758	764
Number of CBSAs	206	203	206
R-squared	0.922	0.924	0.922

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Note: This table reports coefficients' estimates from difference-in-difference specifications 10, 12 and 13. The outcome variable is the yearly growth of the county-level house price index. The explanatory variables is the interaction of financial linkages to Katrina areas $Link$ and an indicator function that equals one in the post-hurricane period and zero otherwise. Column (2) adds an additional interaction with the share of local banks in each county computed in the year before the storm 2004. Column (3) reports the estimates of a triple difference using a third layer of heterogeneity in housing supply elasticity HSE. The panel covers the period 2001:2009. Counties located in the states hit by the hurricane and their adjacent states are dropped from the sample (Counties located in Alabama, Arkansas, Florida, Georgia, Louisiana, Mississippi, Tennessee & Texas are dropped). County-year level controls include lagged versions of the logarithm of the labor force, per capita income, population, Herfindahl-Hirschman Index of local mortgage market concentration, HPI and the unemployment rate. Standard errors are clustered at the county level.

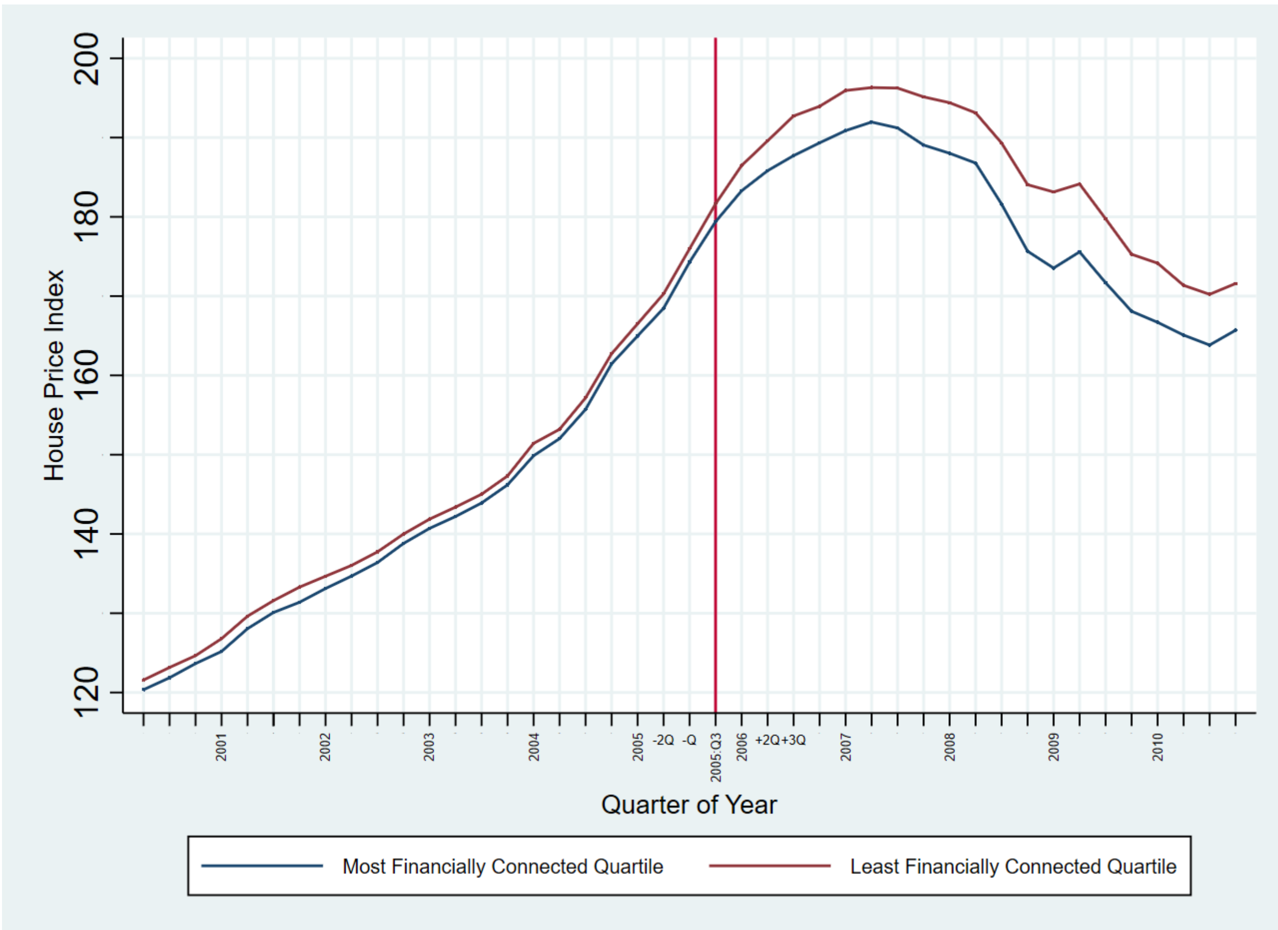
Table 14: **Triple Difference Analysis using Housing Supply Elasticity: Housing Quantities Response (Units, Buildings and Monetary Valuation of Construction Work)**

	(1) $\Delta\, Housing\, Units$	(2) $\Delta\ Buildings$	(3) $\Delta\ Valuation\, (\$MM)$
$I[Time > 2005] \times Link$	2,093	386.0	330.9
	(2,427)	(1,628)	(387.2)
$I[Time > 2005] \times Link \times HSE$	-14,239*	-9,195*	-2,358*
	(8,406)	(4,930)	(1,324)
$I[Time > 2005] \times HSE$	394.7*	251.4*	66.99*
	(237.4)	(137.8)	(37.30)
County-Year Controls	✓	✓	✓
CBSA-Year Fixed Effects	✓	✓	✓
County-Year Observations	6,641	6,641	6,641
Number of Counties	751	751	755
Number of CBSAs	203	203	204
R-squared	0.505	0.639	0.580

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Note: This table reports coefficients' estimates from difference-in-difference-in-difference specification 17. $Link$ is the measure of financial linkages to Katrina areas. HSE refers to the housing supply elasticity measure computed as the inverse of the land unavailability measure of Lutz & Sand (2017). The dependent variables are first differences of annual new residential construction in terms of housing units (Column (1)), buildings (Column (2)) and the monetary valuation of the construction (in $ Million) in Column (3). Counties located in the states hit by the hurricane and their adjacent states are dropped from the sample (Counties located in Alabama, Arkansas, Florida, Georgia, Louisiana, Mississippi, Tennessee & Texas are dropped). The panel covers the period 2001:2009. Negative estimates reported in row (2) suggest a negative housing quantity response for elastic local housing markets. Insignificant results reported in row (1) point to insignificant quantity response for inelastic markets. County-year level controls include lagged versions of the logarithm of the labor force, per capita income, population, Herfindahl-Hirschman Index of local mortgage market concentration, HPI and the unemployment rate. Standard errors are clustered at the county level.

Figure 1: **Evolution of Housing Prices in Local Markets with strong financial ties to disaster areas compared to the ones with weak financial ties. Trends Divergence occurred exactly after Katrina.**



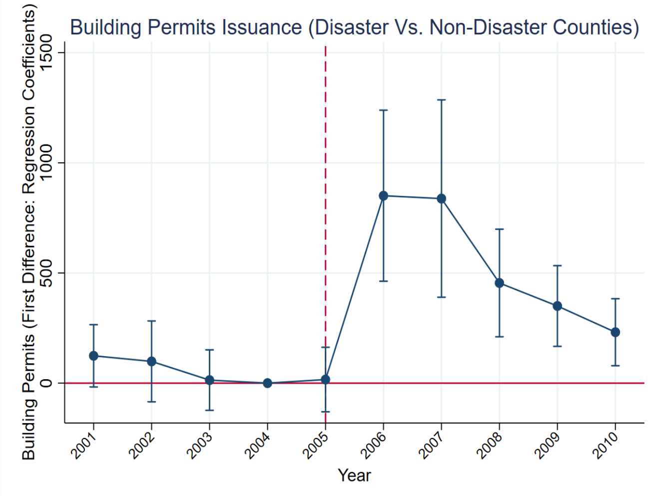
Note: The figure illustrates pre and post trends of Housing Price Indices of the least financially connected quartile of CBSAs (red line) versus the most financially connected quartile of CBSA (blue line) to Katrina-impacted areas holding state constant. Housing prices in the local markets with strong financial ties to Katrina-hit areas witnessed a one-off shock exactly after the storm, which translated to a persistent gap in price levels, relative to the markets with weak financial ties to Katrina areas. The vertical line indicates the exact timing of Katrina (2005:Q3). Trends were parallel prior to the storm and diverged exactly after the storm in 2005:Q4. This sample contains 220 CBSAs in 36 states. CBSAs located in the states hit by the hurricane or their adjacent states are dropped from the sample (CBSAs located in Alabama, Arkansas, Florida, Georgia, Louisiana, Mississippi, Tennessee & Texas are dropped from the sample).

Figure 2: **Financial Inter-linkages to Katrina-hit Regions**

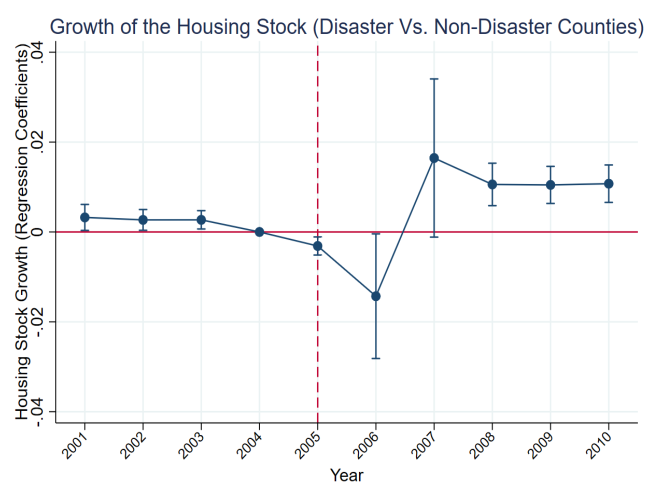
Note: The figure shows a heat map of financial linkages of all urban counties (located within a Core-Based Statistical Area) in the mainland United States, outside of disaster areas and their adjacent states. Alabama, Arkansas, Florida, Georgia, Louisiana, Mississippi, Tennessee and Texas are dropped from the sample. Darker red counties have stronger financial linkages to Katrina-hit areas.

Figure 3: **Abnormal Housing Market Activity in Disaster-Affected Regions in the post-Katrina period supporting the hypothesis of a positive shock to aggregate demand in disaster areas: Prices & Quantities**

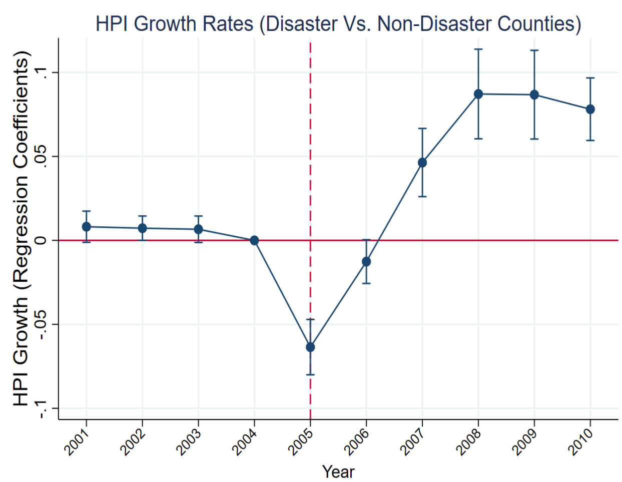
Post-Katrina Surge in Building Permits Issuance



Post-Katrina Surge in Housing Stock Growth



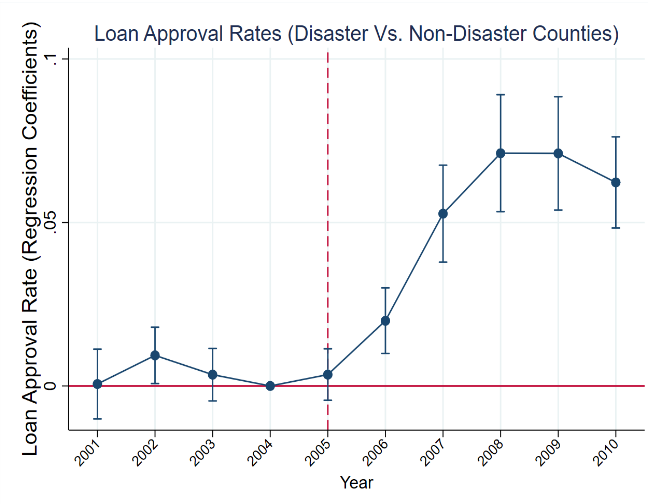
Faster Home Value Appreciation after the storm



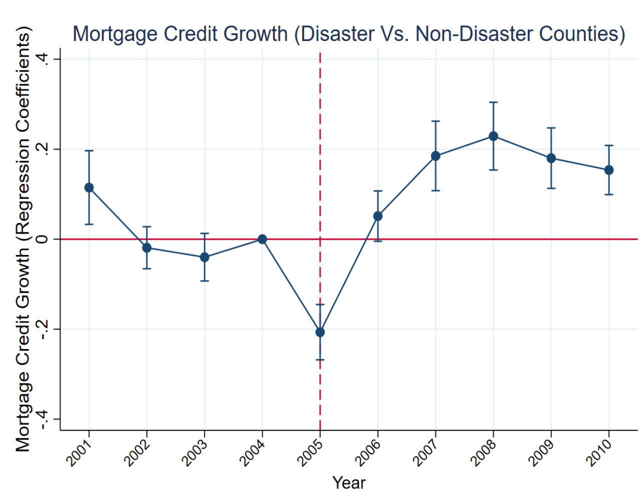
Note: This figure plots the coefficients' estimates of specification 5. The dashed vertical line indicates the year of the hurricane. The three sub-figures document abnormal housing market and construction activities in Katrina-damaged counties compared to the neighboring undamaged counties. This includes abnormal issuance of building permits (top-left figure), abnormal growth of the housing stock (top-right figure) and abnormal housing prices growth (bottom figure) in the post-Katrina period. The estimates point to a negligible and constant difference between the damaged and undamaged counties in the pre-Katrina period. Coefficients are estimated relative to an omitted category (2004) normalized to be zero. Standard errors are clustered at the county level.

Figure 4: **Abnormal Mortgage Market Activity in Disaster-Affected Regions in the post-Katrina period supporting the hypothesis of a positive shock to aggregate demand in disaster areas**

Post-Katrina Surge in Loan Approval Rates in disaster areas

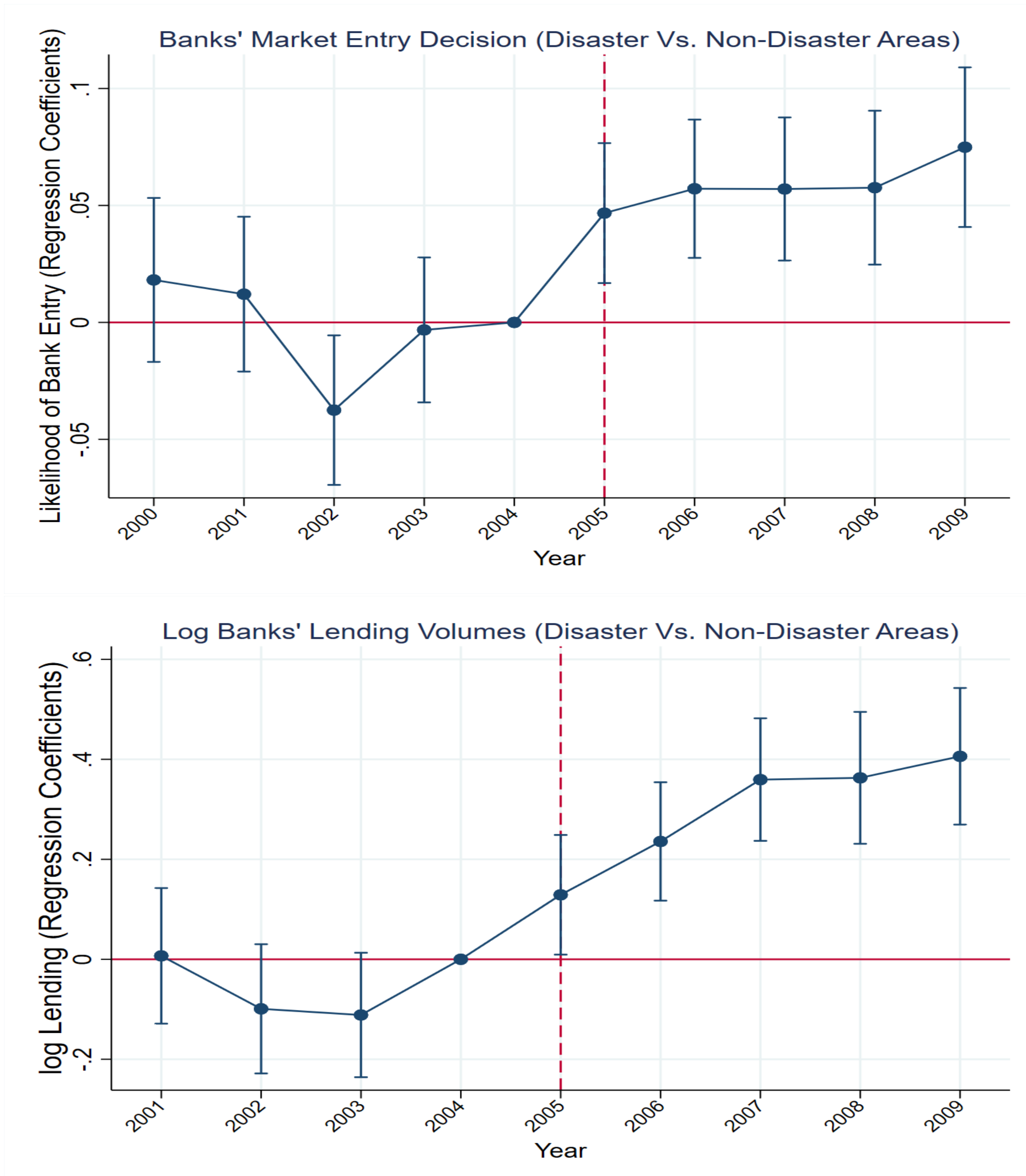


Post-Katrina Surge in the Growth of Mortgage Credit Volumes in disaster areas



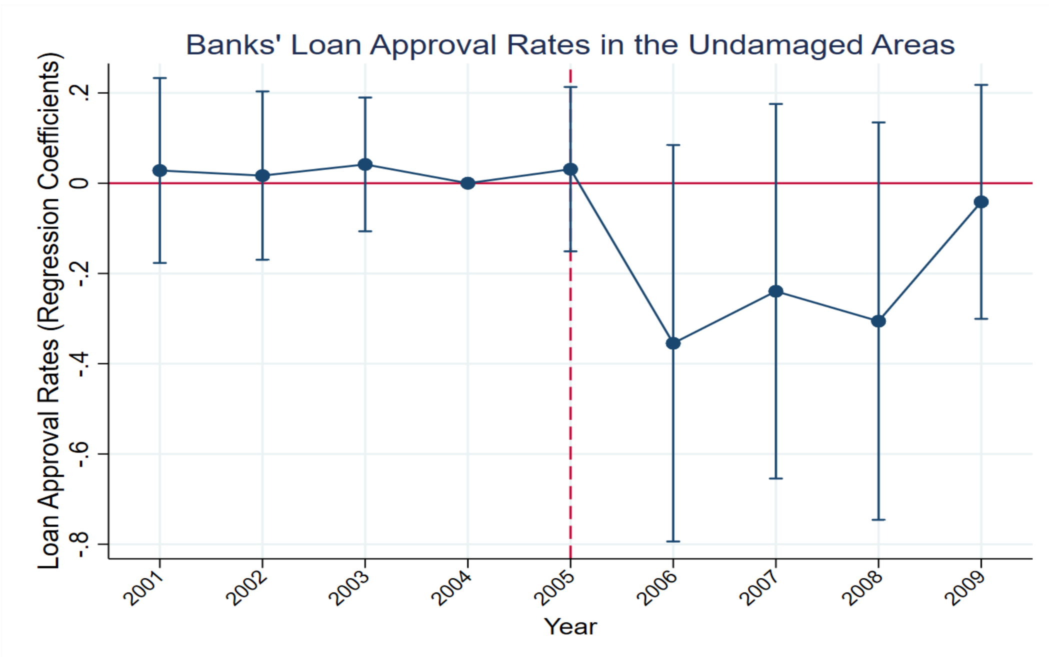
Note: This figure plots the coefficients' estimates of specification 5. The dashed vertical line indicates the year of Katrina. The two sub-figures document the abnormal activity in the mortgage market in the aftermath of the storm including, a sharp increase in the average loan approval rates (left figure) at the county-year level and abnormal growth of credit origination volumes (right figure) in Katrina-damaged counties compared to undamaged counties relative to an omitted category in 2004. Standard errors are clustered at the county level.

Figure 5: **Post-Katrina Surge in Banks' entry and lending in disaster markets**



Note: The upper figure plots the coefficients' estimates of specification 6. The dashed vertical line indicates the year of the hurricane. Each coefficient μ_τ quantifies, at each point of time, the average difference in the likelihood of bank entry to a local market in Louisiana or Mississippi, compared to the likelihood of entry to local markets in the rest of the country, relative to an omitted category μ_{2004} normalized to be zero. The lower graph plots the average percentage change in a bank lending volumes in disaster areas relative to non-disaster areas at each point of time. The pattern on the estimated coefficients indicates an increased likelihood of banks' market entry and lending in Katrina-hit markets compared to other local markets in the U.S. starting 2005, consistent with a significant flow of capital towards disaster areas in the post-Katrina period. All banks' characteristics are held constant. All banks considered are headquartered outside of the U.S. South. Standard errors are clustered at the CBSA level.

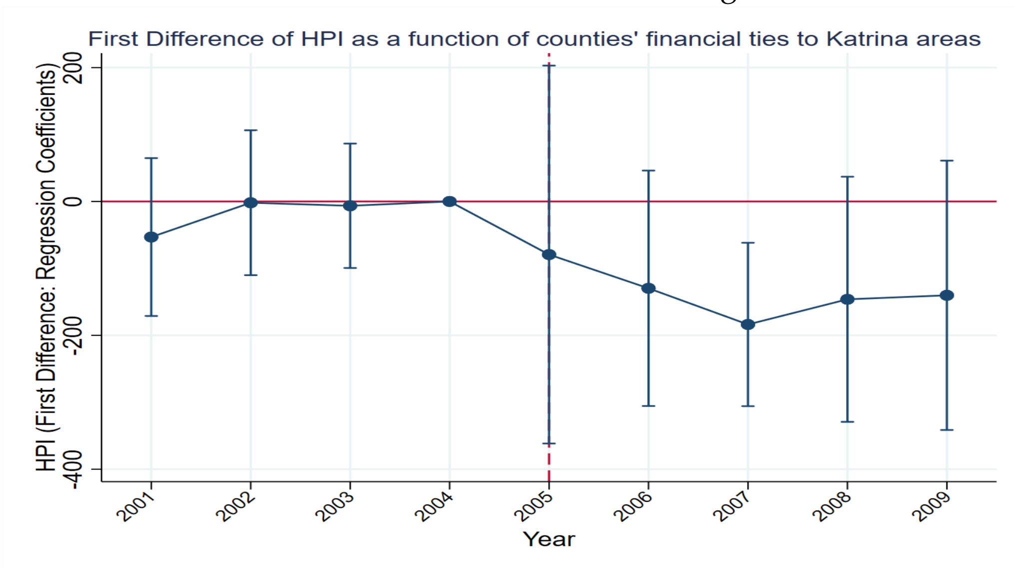
Figure 6: **Abrupt decline in Loan Approval Rates in the Undamaged Regions as a function of Bank's historic market Presence (Geographic Footprint) in Katrina-affected regions**



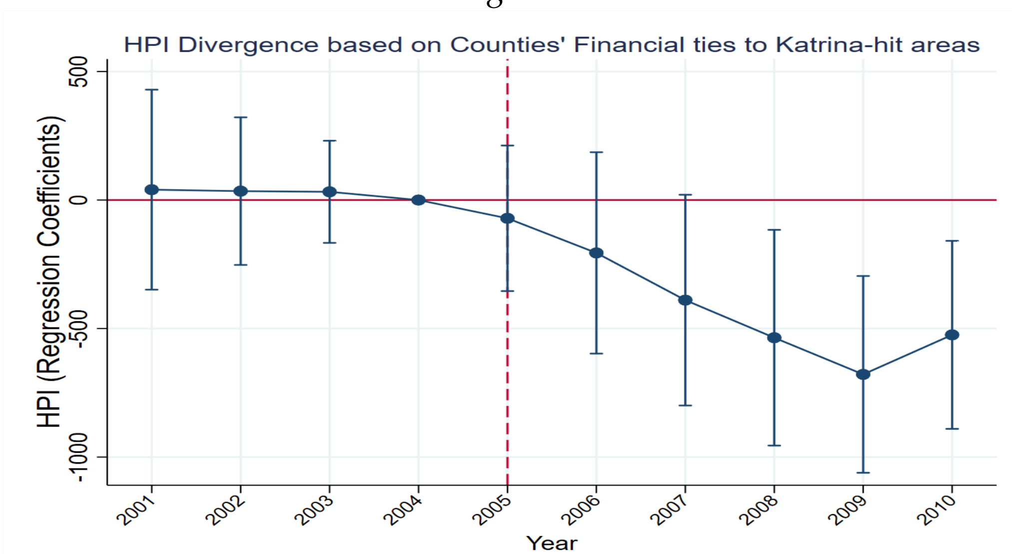
Note: This figure plots the coefficients' estimates using equation 7. The dashed vertical line indicates the year of the hurricane. The figure shows that banks with historic market presence in Katrina areas significantly reduced their loan approval rates in the distant undamaged areas (outside of Katrina-affected areas and their four adjacent states including Alabama, Arkansas, Florida, Georgia, Louisiana, Mississippi, Tennessee and Texas), immediately after the storm. Trends are exactly superimposed for an extended period of time prior to Katrina. Local demand factors are held constant. Bank-Year level control variables include lagged versions of: Total Assets, Interest Expenses to Assets, Non Performing Loans to Assets, Equity ratio, Provisions for loan loss, Unused Commitments and lending in Katrina areas. The average treatment effect estimated in Table 4 points to a 1.24 percentage points decline in bank's loan approval rate, in the post period relative to prior to the storm, for the bank with the average historic geographic footprint in Katrina areas. Standard errors are clustered at the bank level.

Figure 7: **Parallel pre-Katrina Trends and Post-Katrina Divergence between the linked and the less linked Counties**

Changes in HPI (First Difference) in Local Markets (Counties) with strong linkages to disaster areas Vs. Local Markets with weak linkages to disaster areas



HPI in Local Markets (Counties) with strong linkages to disaster areas Vs. Local Markets with weak linkages to disaster areas



Note: The upper figure plots the coefficients' estimates of specification 11. The dashed vertical line indicates the year of Katrina. The dependent variable is the First Difference of House Price Index at the county-year level. The lower figure plots coefficients' estimates of the same model with HPI as the outcome variable, accounting for counties' fixed effects. The variation exploited is the variation in financial linkages to Katrina-hit areas of different counties within the same CBSA. Counties located in the Katrina-hit states and their adjacent states (Alabama, Arkansas, Florida, Georgia, Louisiana, Mississippi, Tennessee & Texas) are dropped from the sample. Trends are superimposed prior to Katrina. Local markets with strong financial linkages to Katrina-hit areas witnessed a significant decline in housing prices immediately after Katrina. Standard errors are clustered at the county level.

The Propagation of Local Credit Shocks:

Evidence from Hurricane Katrina

Online Appendix

Credit Market Tightening in the Undamaged Regions

I provide additional corroborating evidence on a credit market tightening in the areas with strong financial ties to disaster regions, starting immediately after the storm. This tightening coincided with the observed decline in home values. To implement this test, I collect average yearly level data on conventional single family mortgage rates in eighteen large metropolitan areas made available by the FHFA interest rate survey. Similar to the housing prices and construction' analyses, I drop southern metropolitan areas to lessen potential confounding labor market factors related to the hurricane.[40] Using this data, I show that, immediately after the storm, interest rates abruptly increased in the MSAs with strong financial linkages to Katrina-damaged regions relative to the ones with weak linkages, indicating a credit tightening outside of Katrina-damaged regions. To formally document this observation, I estimate the following event study specification:

$$IR_{Mt} = \alpha + \eta_M + \zeta_t + \sum_{\tau \neq 2004} \mathbb{1}[\tau = t] \times Link_M \times \mu_\tau + X_{ist}\Gamma + \epsilon_{Mt} \tag{I}$$

IR_{Mt} is the conventional single family mortgage rate at Metropolitan Area M at year t provided by the FHFA interest rate survey. η_M and ζ_t denote MSA and year fixed effects respectively. X_{ist} are time-varying MSA-level labor market controls. $Link_M$ is the measure of financial linkages of MSA M to Katrina regions. $\mathbb{1}[\tau = t]$ are a set of indicator functions that equal one at their corresponding year and zero otherwise. The coefficients μ_τ's quantify the average difference in conventional mortgage rates each year between different metropolitan areas based on the strength of their financial linkages to disaster areas, relative to an omitted category μ_{2004} normalized to be zero.

Figure A5 plots the set of coefficients μ_τ's. For an extended period of time prior to 2005, financial linkages to disaster areas didn't imply significant differences in mortgage rates between local markets. Starting 2005, the year of Katrina, the estimated μ_τ's suggest a positive shift in interest rates between different metropolitan areas based on the strength of their financial linkages to disaster areas $Link_M$. Table A1 documents an average interest rate differential of 0.36 percentage points in the post storm period compared to before Katrina. Together, results about banks' credit re-allocation away from the undamaged areas and the interest rate differential point to a credit market tightening in the physically undamaged local markets located far away from the areas hit by hurricane Katrina. These findings

[40] After having removed Southern metropolitan areas, the data provided by the FHFA interest rate survey include the following 18 MSAs: Chicago, Cleveland, Columbus, Denver, Detroit, Indianapolis, Kansas City, Milwaukee, Minneapolis-St. Paul, New York, Philadelphia, Phoenix, Pittsburgh, Portland, St. Louis, San Diego, San Francisco, Seattle.

support the hypothesis of a credit-induced decline in home values in the undamaged regions after the storm.

Variables Definitions for the Bank-Level Analysis:

Mortgage Loan Approval Rates are computed, using HMDA loan level data, following Antoniades (2016) and using the applications that ultimately led to an approval or a denial decision. This includes three types of applications: 1) Approved applications that led to loan originations, 2) Approved Applications that were but not accepted (by the applicants) and 3) loan applications that were denied by financial institutions. Accordingly, applications withdrawn by the applicant, files closed for incompleteness, loans purchased by the institution (already originated by a financial institution) are not considered for the computation of loan approval rates. Similar to Antoniades (2016), I consider (1) and (2) as approvals as they both signal the willingness of the financial institution to extend credit to the applicant. Hence, I compute the Bank-CBSA-Year loan approval rate as the ratio of the sum of loan entries reporting (1) and (2) as outcomes to the sum of loans reporting (1), (2) and (3) as outcomes.

Regarding banks' balance sheet variables, they are constructed from the end-of-year Quarterly Report of Condition and Income (Call Report) maintained by the Federal Reserve Bank of Chicago, as follows:

- Asset Size is reported as item RCFD2170.
- Core Deposits are computed the sum of Total transaction account (rcon2215) + Money market deposits accounts MMDA's (rcon6810) + Other non-transaction savings deposits (rcon0352) + Total time deposits of less than $100,000$ (rcon6648) - Total brokered retail deposits issued in denominations of less than $100,000$ (rcon2343).
- Total Unused Commitments are reported as item rcfd342.
- Loans secured by real estate are reported as item rcfd1410.
- Commercial and industrial loans are reported as item rcfd1766.
- Total interest expenses are reported as item riad4073.
- Total transaction accounts are reported as item rcon2215.
- Interest On deposits are reported riad4170.

- Non Performing Loans are computed as the sum of total loans and lease financing receivables: past due 90 days or more and still accruing (rcfd1407) and total loans and lease financing receivables: nonaccrual (rcfd1403).
- Total equity capital is reported as item rcfd3210.
- Liquidity is computed as securities held to maturity (rcfd1754), securities available for sale (rcfd1773), federal funds sold and securities purchased under agreements to resell (rcfd1350), non-interest bearing balances and currency and coin (rcfd0081) and interest-bearing balances (rcfd0071).
- Provision for loan and lease losses are reported as (riad4230).

Appendix Tables and Figures

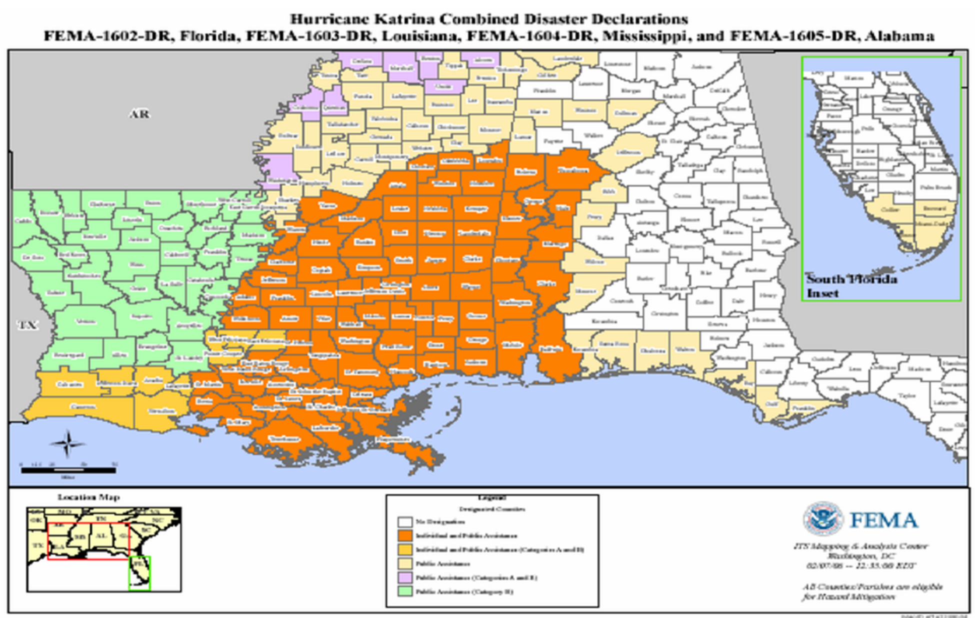
Table A1: **Post-Katrina Increase in Interest rates in the financially linked MSAs relative to the weakly linked MSAs (Outside of disaster areas)**

	Mortgage Rates
$I[Time > 2005] \times Link_M$	0.361*
	(0.194)
MSA controls	✓
Year FE	✓
MSA FE	✓
MSA-Year Observations	162
Number of MSAs	18
R-squared	0.970

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

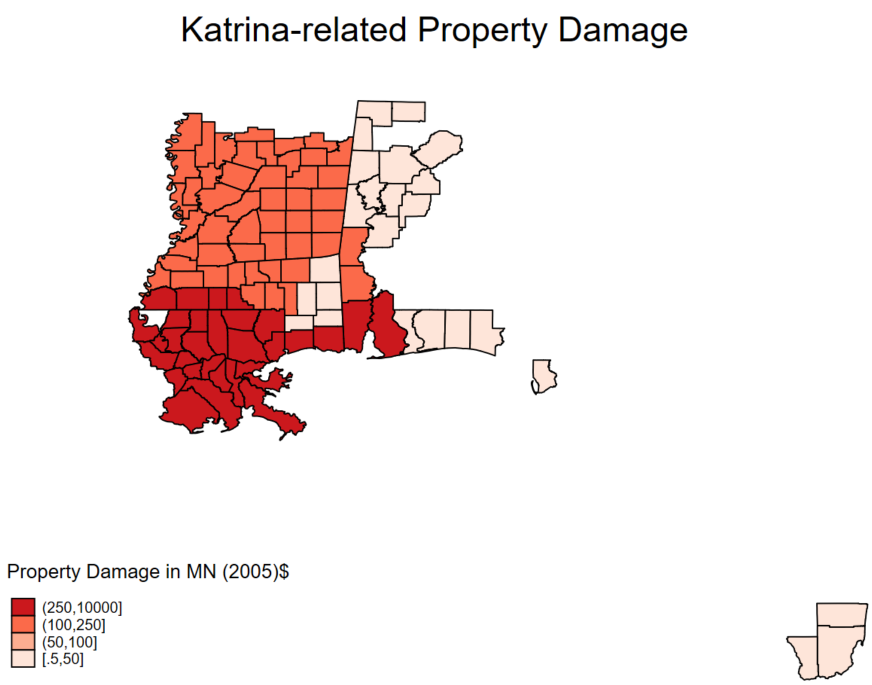
Note: The estimate presented at this table quantifies the average Contract interest rate differential between metropolitan areas based on the strength of their financial linkages to Katrina areas, after the storm compared to before the storm. The period of study is 2001:2009. The dependent variable is the contract interest rate for single family conventional mortgages at MSA M at year t. The estimate points to an average 0.36 percentage points increase in interest rates in the areas with strong financial ties to Katrina areas in the post-Katrina period compared to the areas with weak linkages to disaster areas, consistent with a credit tightening after the storm. Eighteen MSAs are included in this test and are all outside of disaster areas and include: Chicago, Cleveland, Columbus, Denver, Detroit, Indianapolis, Kansas City, Milwaukee, Minneapolis-St. Paul, New York, Philadelphia, Phoenix, Pittsburgh, Portland, St. Louis, San Diego, San Francisco, Seattle. MSA controls include lagged versions of the size of the labor force and unemployment rates. Standard Errors are clustered at the MSA level.

Figure A1: **FEMA Katrina-related Disaster Declarations**



Note: The figure shows the areas that were declared disaster areas, in relation to hurricane Katrina, by FEMA's disaster declarations DR 1602 for Florida declared in 8/28/2005, DR 1603 for Louisiana declared in 8/29/2005, DR 1604 for Mississippi declared in 8/29/2005 and DR 1605 for Alabama in 8/29/2005. These regions become eligible for individual and / or public federal assistance. Source: Baen J. and Dermisi S. (2007) and FEMA's Disaster Declarations Summary File.

Figure A2: **Property Damage due to Katrina**

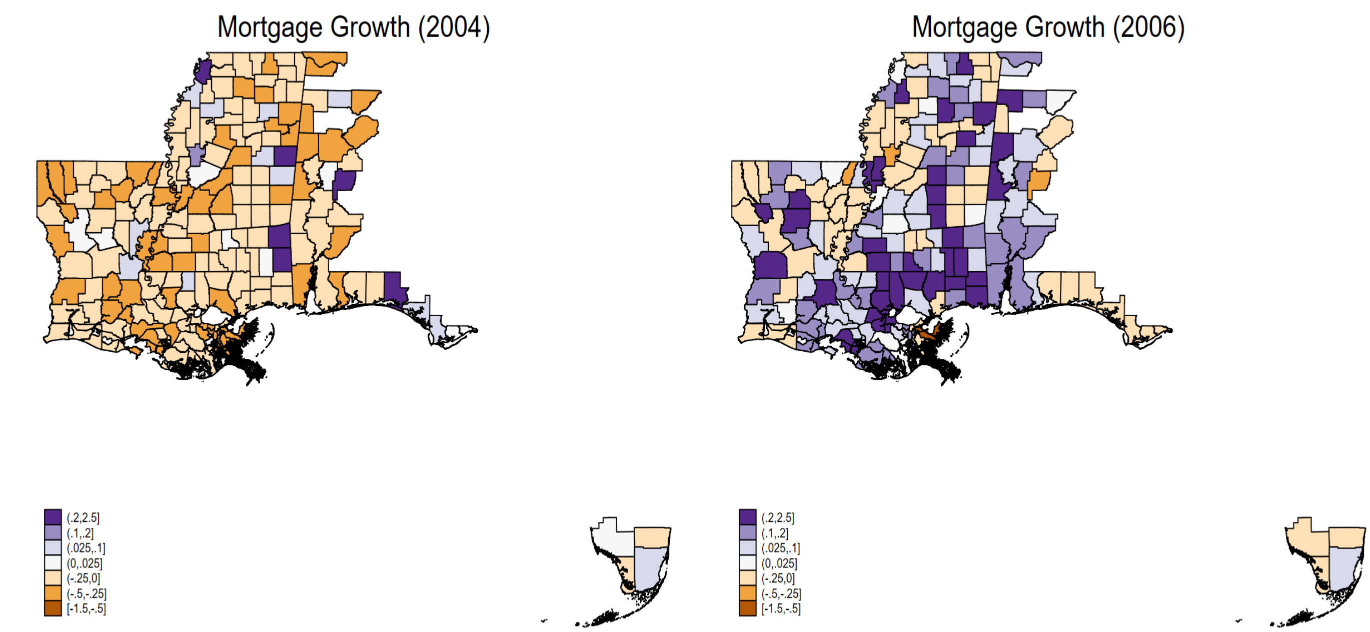


Note: Property Damage reported by the Spatial Hazard Events and Losses Database for the United States SHELDUS maintained by Arizona State University and disaggregated at the county level. The total property damage in the areas considered amounts to $74.15 BN (2005 $).

Figure A3: **Abnormal Mortgage Market Activity in Disaster-Affected Regions in the post-Katrina period compared to the pre-storm period**

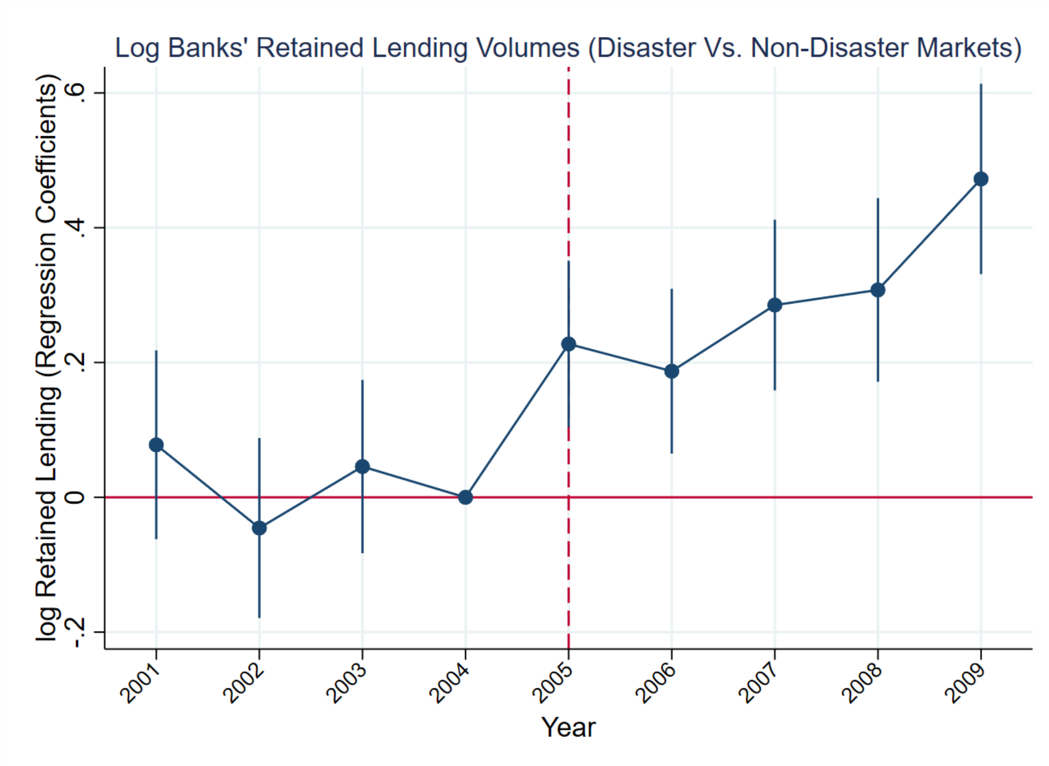
Weak Mortgage Growth before Katrina (2004)

Booming local mortgage markets after Katrina (2006)



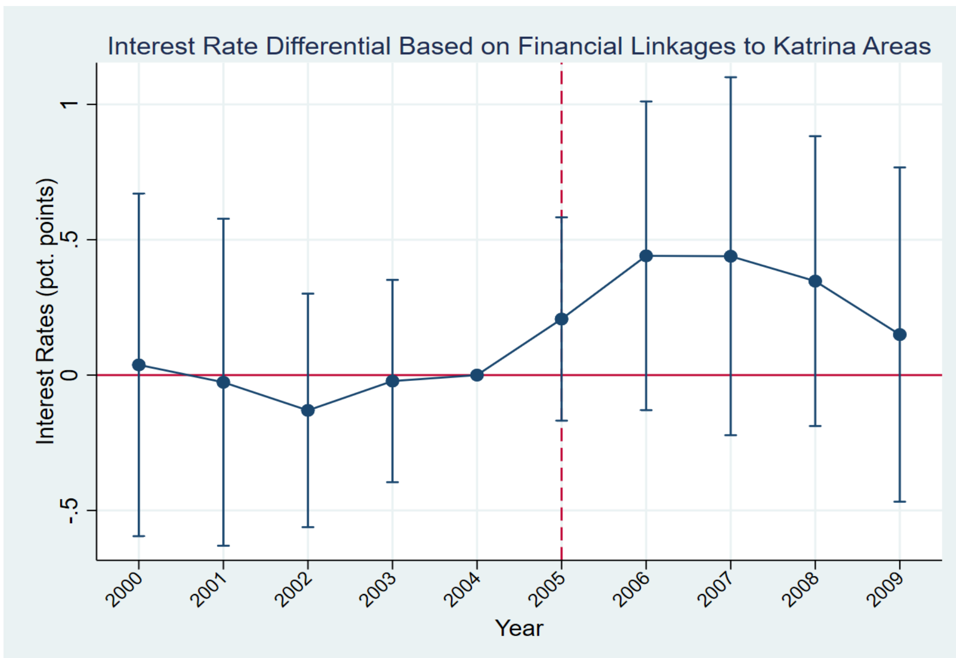
Note: This figure makes a simple comparison of mortgage growth rates of total mortgage origination volumes per county before and after the storm in disaster areas. Orange areas reflect weak mortgage growth while the purple indicates high growth rates of mortgage origination volumes. Immediately after the storm, most disaster counties shifted from orange to purple between 2004 and 2006 reflecting a mortgage boom in disaster areas. The areas considered in this simple comparison are the areas that were labelled by the Federal Emergency Management Agency (FEMA) as 'Major Disaster Declaration' areas in the aftermath of hurricane Katrina. Source: HMDA Data.

Figure A4: **Post-Katrina Surge in Loan Retention in disaster markets**



Note: This figure plots the average percentage change in banks' lending volumes originated in disaster areas and retained on banks' balance sheets relative to origination and retention in non-disaster areas, at each point of time. The pattern on the estimated coefficients indicates increased amounts of lending originated and retained on banks' balance sheets in disaster areas after the storm. All banks' characteristics are held constant. All banks considered are headquartered outside of the U.S. South. Standard errors are clustered at the CBSA level.

Figure A5: **Post-Katrina Increase in Interest rates in the financially linked MSAs relative to the weakly linked MSAs (Outside of disaster areas)**



Note: This figure plots the coefficients' estimates μ_τ's of Appendix equation I. It plots the evolution of the interest rate differential between different Metropolitan Areas based on the strength of their financial linkages to Katrina regions. The dashed vertical line indicates the year of Katrina. Prior to the storm, no statistically significant difference in interest rates is observed. Starting 2005, a positive interest differential emerged between the areas with strong financial linkages to disaster areas and the areas with weak linkages. Eighteen MSAs are included in this test and are all outside of disaster areas and include: Chicago, Cleveland, Columbus, Denver, Detroit, Indianapolis, Kansas City, Milwaukee, Minneapolis-St.Paul, New York, Philadelphia, Phoenix, Pittsburgh, Portland, St. Louis, San Diego, San Francisco, Seattle. Standard errors are clustered at the MSA level.

List of CBSA included in the CBSA-Level Analysis:

- Akron, OH
- Albany-Lebanon, OR
- Albany-Schenectady-Troy, NY
- Albuquerque, NM
- Altoona, PA
- Ames, IA
- Anchorage, AK
- Ann Arbor, MI
- Appleton, WI
- Asheville, NC
- Atlantic City-Hammonton, NJ
- Bakersfield, CA
- Baltimore-Columbia-Towson, MD
- Battle Creek, MI
- Bay City, MI
- Beckley, WV
- Bellingham, WA
- Bend, OR
- Billings, MT
- Binghamton, NY
- Bismarck, ND
- Blacksburg-Christiansburg, VA
- Bloomington, IN
- Bloomsburg-Berwick, PA
- Boise City, ID

- Boulder, CO
- Bowling Green, KY
- Bremerton-Silverdale-Port Orchard, WA
- Buffalo-Cheektowaga, NY
- Burlington, NC
- Canton-Massillon, OH
- Carbondale-Marion, IL
- Carson City, NV
- Casper, WY
- Cedar Rapids, IA
- Chambersburg-Waynesboro, PA
- Champaign-Urbana, IL
- Charleston, WV
- Charleston-North Charleston, SC
- Charlottesville, VA
- Cheyenne, WY
- Chico, CA
- Cleveland-Elyria, OH
- Coeur d'Alene, ID
- Colorado Springs, CO
- Columbia, MO
- Columbia, SC
- Columbus, IN
- Columbus, OH
- Corvallis, OR
- Danville, IL
- Decatur, IL

- Denver-Aurora-Lakewood, CO
- Des Moines-West Des Moines, IA
- Dover, DE
- Dubuque, IA
- Durham-Chapel Hill, NC
- East Stroudsburg, PA
- Eau Claire, WI
- El Centro, CA
- Elizabethtown-Fort Knox, KY
- Elkhart-Goshen, IN
- Elmira, NY
- Enid, OK
- Erie, PA
- Eugene-Springfield, OR
- Fairbanks, AK
- Farmington, NM
- Fayetteville, NC
- Flagstaff, AZ
- Flint, MI
- Florence, SC
- Fond du Lac, WI
- Fort Collins, CO
- Fort Wayne, IN
- Fresno, CA
- Gettysburg, PA
- Glens Falls, NY
- Goldsboro, NC

- Grand Island, NE
- Grand Junction, CO
- Grand Rapids-Kentwood, MI
- Grants Pass, OR
- Great Falls, MT
- Greeley, CO
- Green Bay, WI
- Greensboro-High Point, NC
- Greenville, NC
- Greenville-Anderson, SC
- Hanford-Corcoran, CA
- Harrisburg-Carlisle, PA
- Harrisonburg, VA
- Hickory-Lenoir-Morganton, NC
- Hilton Head Island-Bluffton, SC
- Idaho Falls, ID
- Indianapolis-Carmel-Anderson, IN
- Iowa City, IA
- Ithaca, NY
- Jackson, MI
- Jacksonville, NC
- Janesville-Beloit, WI
- Jefferson City, MO
- Johnstown, PA
- Joplin, MO
- Kahului-Wailuku-Lahaina, HI
- Kalamazoo-Portage, MI

- Kankakee, IL
- Kennewick-Richland, WA
- Kingston, NY
- Kokomo, IN
- Lake Havasu City-Kingman, AZ
- Lancaster, PA
- Lansing-East Lansing, MI
- Las Cruces, NM
- Las Vegas-Henderson-Paradise, NV
- Lawrence, KS
- Lawton, OK
- Lebanon, PA
- Lexington-Fayette, KY
- Lima, OH
- Lincoln, NE
- Longview, WA
- Lynchburg, VA
- Madera, CA
- Madison, WI
- Manhattan, KS
- Mankato, MN
- Mansfield, OH
- Medford, OR
- Merced, CA
- Michigan City-La Porte, IN
- Midland, MI
- Milwaukee-Waukesha, WI

- Missoula, MT
- Modesto, CA
- Monroe, MI
- Morgantown, WV
- Mount Vernon-Anacortes, WA
- Muncie, IN
- Muskegon, MI
- Napa, CA
- New Bern, NC
- Niles, MI
- Ocean City, NJ
- Ogden-Clearfield, UT
- Oklahoma City, OK
- Olympia-Lacey-Tumwater, WA
- Oshkosh-Neenah, WI
- Owensboro, KY
- Oxnard-Thousand Oaks-Ventura, CA
- Parkersburg-Vienna, WV
- Peoria, IL
- Phoenix-Mesa-Chandler, AZ
- Pittsburgh, PA
- Pocatello, ID
- Provo-Orem, UT
- Pueblo, CO
- Racine, WI
- Raleigh-Cary, NC
- Rapid City, SD

- Reading, PA
- Redding, CA
- Reno, NV
- Richmond, VA
- Riverside-San Bernardino-Ontario, CA
- Roanoke, VA
- Rochester, MN
- Rochester, NY
- Rockford, IL
- Rocky Mount, NC
- Sacramento-Roseville-Folsom, CA
- Saginaw, MI
- St. Cloud, MN
- St. George, UT
- Salem, OR
- Salinas, CA
- Salt Lake City, UT
- San Diego-Chula Vista-Carlsbad, CA
- San Jose-Sunnyvale-Santa Clara, CA
- San Luis Obispo-Paso Robles, CA
- Santa Cruz-Watsonville, CA
- Santa Fe, NM
- Santa Rosa-Petaluma, CA
- Scranton–Wilkes-Barre, PA
- Sheboygan, WI
- Sierra Vista-Douglas, AZ
- Sioux Falls, SD

- Spartanburg, SC
- Spokane-Spokane Valley, WA
- Springfield, IL
- Springfield, MO
- Springfield, OH
- State College, PA
- Staunton, VA
- Stockton, CA
- Sumter, SC
- Syracuse, NY
- Terre Haute, IN
- Toledo, OH
- Topeka, KS
- Trenton-Princeton, NJ
- Tucson, AZ
- Tulsa, OK
- Utica-Rome, NY
- Vallejo, CA
- Vineland-Bridgeton, NJ
- Visalia, CA
- Walla Walla, WA
- Waterloo-Cedar Falls, IA
- Watertown-Fort Drum, NY
- Wausau-Weston, WI
- Wenatchee, WA
- Wichita, KS
- Williamsport, PA

- Wilmington, NC
- Winston-Salem, NC
- Yakima, WA
- York-Hanover, PA
- Yuba City, CA
- Yuma, AZ