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Essays on Financial and Public Economics

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Abstract

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By

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This dissertation presents two independent, but interrelated, essays on financial decision making. The first essay shows that, in response to unemployment shocks, older workers precipitously deplete their 401(k)s, particularly after the waiving of the early withdrawal penalty on unemployment-motivated withdrawals at age 55. This paper shows that Unemployment Insurance (UI) keeps older workers from depleting their 401(k) assets following job losses. UI also incentivizes older unemployed workers to delay claiming their Social Security (SS) benefits beyond the earliest age of eligibility, 62. Overall, UI enhances the retirement income of the individuals having a history of late-career layoffs by helping them preserve their 401(k) assets, the return on these assets and opt for a higher stream of Social Security benefits.

The second essay studies banks' geographic portfolio reallocation in response to hurricane Katrina. Most importantly, it shows this reallocation of resources toward disaster-impacted had real effects on housing markets in the undamaged areas through a credit supply channel. This paper shows that a local credit shock, induced by hurricane Kat-

rina, 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. Consequently, 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.

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Samir Elsadek Mahmoudi

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ACCEPTANCE

This dissertation was prepared under the direction of the candidate's Dissertation Committee. It has been approved and accepted by all members of that committee, and it has been accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy in Economics in the Andrew Young School of Policy Studies of Georgia State University.

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Dedication

My late uncle Abdullah would have loved to attend my dissertation defense. I dedicate this work to him. His support was crucial in the most critical moments.

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During my doctoral coursework, I also exploited the synergies between the Department of Economics and our Business School. In this regard, I have to thank Vikas Agarwal, Scott Murray and George Zanjani for many fruitful and encouraging discussions. Hadiye Aslan and Dalida Kadyrzhanova gave a very motivating corporate finance sequence that definitely expanded my horizons and gave me additional insights on empirical methods and different data sources. Being surrounded by these first-rate economists raised my expectations and my standards. Higher expectations did indeed improve my performance. I am grateful for the type of interactions I was able to get at graduate school.

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Chapter 1

Late-career Unemployment Shocks, Pension Outcomes and Unemployment Insurance

1.1 Introduction

What is the effect of late-career unemployment shocks on retirement income? Late career layoffs leave workers vulnerable to a lower likelihood of re-employment [Chan and Huff Stevens 2001; Hirsch, Macpherson, and Hardy 2000], longer unemployment durations [GAO 2012], a post-displacement wage penalty [Shapiro and Sandell 1985], age discrimination [Neumark, Burn, and Button 2019] and deteriorated health [Coile, Levine, and McKnight 2014]. Their reduced job opportunities and short remaining career time make it less likely for older workers to replenish their retirement savings after an unemployment-induced depletion. Unemployment shocks could also motivate early Social Security (SS) claiming leaving individuals with a lower stream of benefits throughout retirement. What role can Unemployment Insurance (UI) play to alleviate these constraints? Addressing these questions help explain the factors driving retirement income security of nearly a million unemployed workers aged 55-64 in the United States.[1]

I show that following a job loss, older workers initiate a fast depletion of their defined-contribution (DC) 401(k) wealth, followed by a similar depletion of their Individual Retirement Accounts (IRAs), well before the Full Retirement Age (FRA)[2]. This early depletion of private pensions makes Social Security (SS) wealth their main remaining asset dedicated to retirement. These pension decumulation decisions by the unemployed are further intensified by the removal of the Early Withdrawal Penalty (EWP) on 401(k)s, at age 55 for job losers, and on IRAs, at age $59\frac{1}{2}$ for all individuals. Hence, these asset decumulation decisions are highly responsive to the tax-price of withdrawals from Tax-Deferred pension Accounts (TDAs).

This paper shows that Unemployment Insurance (UI) keeps older workers from depleting their 401(k) pension assets following job losses. UI has a similar effect on older unemployed workers' SS take-up timing decisions. Following a job loss, SS-eligible individuals with access to more generous UI are more likely to delay SS benefits claiming beyond the earliest age of eligibility, 62. UI significantly enhances retirement income for the workers with a history of late-career layoffs in two ways. First, reducing unemployment-motivated 401(k) asset leakage helps older workers preserve the returns on their retirement investments. Second, incentivizing older job losers to delay SS claiming results in a higher expected present value of their stream of benefits. Overall, UI, a policy mainly aiming at easing short-term liquidity constraints, helps older workers improve their long-term private pensions and social security outcomes throughout retirement.

Using two panels of data from the Survey of Income and Program Participation (SIPP), covering the periods 1996-1999 and 2001-2003, I link workers' labor market histories to their 401(k) pension outcomes and their SS benefit receipt histories. I exploit a tax code

1. Data from the Bureau of Labor Statistics at https://www.bls.gov/web/empsit/cpseea36.htm and GAO (2012).

2. The FRA, the age of workers' eligibility for the Social Security Primary Insurance Amount, is 65 for the time frame studied in this paper.

exception that waives the EWP on withdrawals from 401(k) plans following a job separation during or after the year the employee reaches age 55. This exception creates a discontinuity in the tax price of unemployment-induced withdrawals around that age. I document significant asset flows out of 401(k) plans in response to job losses occurring after age 55. A job loss just after age 55 resulted in a 51 percent larger decline in 401(k) pension savings, compared to a job loss just before 55, equivalent to the withdrawal of $5,900 of 401(k) assets upon job loss. The absence of contemporaneous inflows into IRAs suggests that these funds leaked out of the tax-deferred system to cover unemployment-related or non-tax-deferred expenses. The parallel trends of 401(k) savings between job losers and employed workers younger than 55 support a causal interpretation of this finding. Similarly, in response to the complete removal of the EWP on IRA withdrawals at age $59\frac{1}{2}$, I report large layoff-induced depletion of IRA wealth of the unemployed immediately after that age. By the age of eligibility for early SS benefits, 62, workers with a history of late-career layoffs had already significantly depleted their private pensions, making social security their main source of income dedicated to retirement.

I then estimate the effect of UI generosity on DC pension decumulation of older job losers by comparing the trends of 401(k) savings among the unemployed and the employed, in response to state-level changes in UI benefits generosity, holding other state-time factors constant. I show that a $1,000 increase in states' regular maximum unemployment benefits, during the course of an unemployment spell, reduces the negative effect of a job loss on 401(k) savings by enabling older unemployed workers to preserve an average of about $750 of 401(k) savings from depletion during unemployment. These effects are stronger among the most liquidity constrained workers, namely those with few financial assets outside of retirement accounts.

I conduct a similar analysis of UI benefit generosity on social security claiming behavior following a job loss. I compare the likelihood of SS benefits claiming between older workers subjected to job loss shocks at different ages and residing in states with different levels of UI benefits generosity. Late-career job loss shocks lead to immediate SS claiming once individuals become SS-eligible, at age 62, consistent with Coile and Levine (2007, 2011) and Card, Maestas, and Purcell (2014). Yet, I show that among the SS-eligible job losers, those with access to more generous UI are more likely to delay SS benefits claiming beyond the earliest age of eligibility.

These findings make three main contributions to the literature and to the formulation of public policies targeting older workers. First, while many studies document the consumption smoothing effects of UI [Browning and Crossley 2009; East and Kuka 2015; Gruber 1997], this paper is the first to show that UI enhances retirement income for the individuals with a history of late-career layoffs by helping them preserve their 401(k) savings from depletion during unemployment spells and by incentivizing them to delay their social security take-up decision beyond age 62. These two long-term effects of UI on retirement income security add to the set of factors considered in the design of optimal UI policy.

Second, I exploit a sharp discontinuity in the tax price of accessing 401(k) accounts by job losers around age 55 based on the timing of the job loss to estimate the responsiveness of pension flows to the removal of the EWP. This elasticity estimate contributes to the current debate on the optimal liquidity of pension accounts [Beshears et al. 2015] and is crucially needed to infer workers' responses to the usage of the EWP as a policy lever to alleviate financial hardships during downturns. For instance, the 2020 Coronavirus Aid, Relief, and Economic Security Act (CARES) waived the EWP on coronavirus-related pension distributions, including distributions made to alleviate financial hardships resulting from corona-related layoffs or reduced hours of work. While this measure can reduce the cost of funds for the unemployed, the removal of the EWP may trigger an early depletion of pension savings with significant consequences on future retirement income. Estimates provided by this paper help quantify the effects of the removal of the penalty on job loss-motivated pension withdrawals and consequently, on retirement income. They also serve as guidance for policymakers considering the suspension of the EWP as a policy lever in response to future downturns.

Third, there is limited evidence to date on the effect of labor market shocks on defined contribution pensions, particularly due to the lack of longitudinal data linking workers' labor market histories to the evolution of their pension wealth [Mitchell and Turner 2010]. This data deficiency limited prior research on pre-retirement pension withdrawals to tax returns data with little information on contemporaneous labor market outcomes [Amromin and Smith 2003; Argento, Bryant, and Sabelhaus 2015; Chang 1996]. I overcome this challenge using the Survey of Income and Program Participation that allows me to construct detailed labor market histories of workers throughout the panel and link them to their 401(k)s, IRAs as well as their SS benefit receipt over time.

1.2 Policy background

1.2.1 Tax-deferred pension accounts: 401(k) and IRA plans

To reduce workers' incentives for pre-retirement withdrawals from 401(k) plans, the 1986 Tax Reform Act (TRA) imposed a 10% penalty in addition to applicable income taxes, on 401(k) distributions made prior to the $59\frac{1}{2}$ age threshold. A similar early withdrawal penalty applies to IRAs. However, a number of hardship-related exceptions provide workers with penalty-free access to their 401(k)s to allow for some flexibility to use pension savings in response to transitory shocks prior to that age. This includes withdrawals made following a job separation during or after the year the employee reaches age 55.[3] This exception does not apply for IRAs.

Following job separations, workers have two options to manage the savings they accumulated in their former employers' defined contribution plans. First, they can preserve

3. Internal Revenue Code Section 72(t)(2)(A)(v). Other exceptions include, but are not limited to, distributions made because of total and permanent disability or substantial un-reimbursed medical expenses.

the tax-deferred status of their savings. They can do this by keeping their funds with their old employers' plans or transfer them to their new plans with their new firms. Alternatively, they can transfer them into an IRA (an IRA *rollover*). Second, employees can also cashout their pension savings to finance their consumption during an unemployment spell or to make non-tax-deferred investments. The second option is considered to be a leakage of funds outside of the pension system, corresponding to the usage of tax-deferred pension savings for non-retirement purposes. These early distributions are penalized by a 10% EWP unless they qualify for a tax code exception, such as a job separation after age 55.

The U.S. defined contribution system provides significant flexibility to respond to transitory income shocks, by allowing relatively less costly pre-retirement withdrawals compared to other developed countries [Beshears et al. 2015]. This flexibility allows significant pre-retirement leakage of retirement savings out of the tax-deferred system. These early withdrawals are common and usually associated with income shocks [Argento, Bryant, and Sabelhaus 2015] and are typically prevalent among liquidity constrained workers who are less likely to *rollover* their funds into tax-qualified accounts following a job separation [Chang 1996]. The size of this leakage is a policy concern, with Argento, Bryant, and Sabelhaus (2015) estimating a leakage of 40 cents for each dollar of pension contributions made prior to age 55. An argument for this flexibility is that the option to withdraw funds prior to retirement, could be an incentive for additional contributions [Poterba and Venti 2001]. In contrast, Beshears et al. (2020) argue that early withdrawal penalties do not reduce workers' willingness to commit to savings vehicles.

A *rollover* of 401(k) savings into an IRA preserves the tax-deferred status of pension assets. Additionally, IRAs allow workers to delay paying taxes on their contributions. Contributions cannot exceed an annually defined contribution limit or yearly the taxable compensation of the individual, where compensation is generally defined by the IRS as earned income.[4] However, contribution limits do not apply to *rollovers* of pension savings. To limit the extent of possible tax-deferral, IRA holders are required to start making Required Minimum Distributions (RMDs) at the age threshold $70\frac{1}{2}$.[5]

1.2.2 Social security

Social Security retirement benefits can be claimed at any age starting age 62, but actuarial adjustments are made based on the age of benefits initiation. Claiming at the full retirement age, 65 for the time frame of this study, guarantees a 100% of one's Primary Insurance Amount (PIA) determined based on the worker's lifetime earnings. Claiming prior to the FRA reduces the benefits amount by $\frac{5}{9}$ % of the PIA for each month of difference between the FRA and the age of SS benefits initiation. Accordingly, for the sample studied in the paper the penalty for claiming at 62 is %20 of the PIA.[6] Similarly, delaying benefits claiming by one month, from 62 to 62 and a month, is equivalent to purchasing a one month deferred annuity providing a lifelong benefit of $\frac{5}{9}$ % of the PIA in exchange for a one time premium of 80% of the PIA. A large body of literature emphasizes the actuarial advantages of delaying the benefits initiation decision [Coile et al. 2002; Shoven and Slavov 2014; Munnell and Soto 2005]. However, 62 is the most popular age for benefits initiation with about 40% of all workers claiming at 62 [Munnell and Chen 2015].

1.3 Conceptual framework

Older workers face a trade-off between unemployment risk and longevity risk; the risk of running out of funds at old ages. Pre-retirement pension withdrawals reduce

4. Accordingly, unemployment and social security benefits are generally not considered earned income for IRA contribution purposes.

5. RMD rules also apply to employer-sponsored plans such as 401(k)s. Similar to the EWP, RMDs have been recently suspended by the CARES act.

6. The 1983 reform increased the penalty of early claiming by increasing the full retirement age. However, cohorts impacted by this reform reached their new full retirement age starting 2004 which is beyond the time frame of this study.

the financial resources available for retirement funding. Following a late-career job loss, workers have three potential options to tap: their defined-contribution 401(k) plans, their IRAs or their SS Wealth. To make these decisions, older unemployed workers choose the amount of their pre-retirement pension distribution D_t that maximizes the discounted sum of their utilities prior and after retirement:

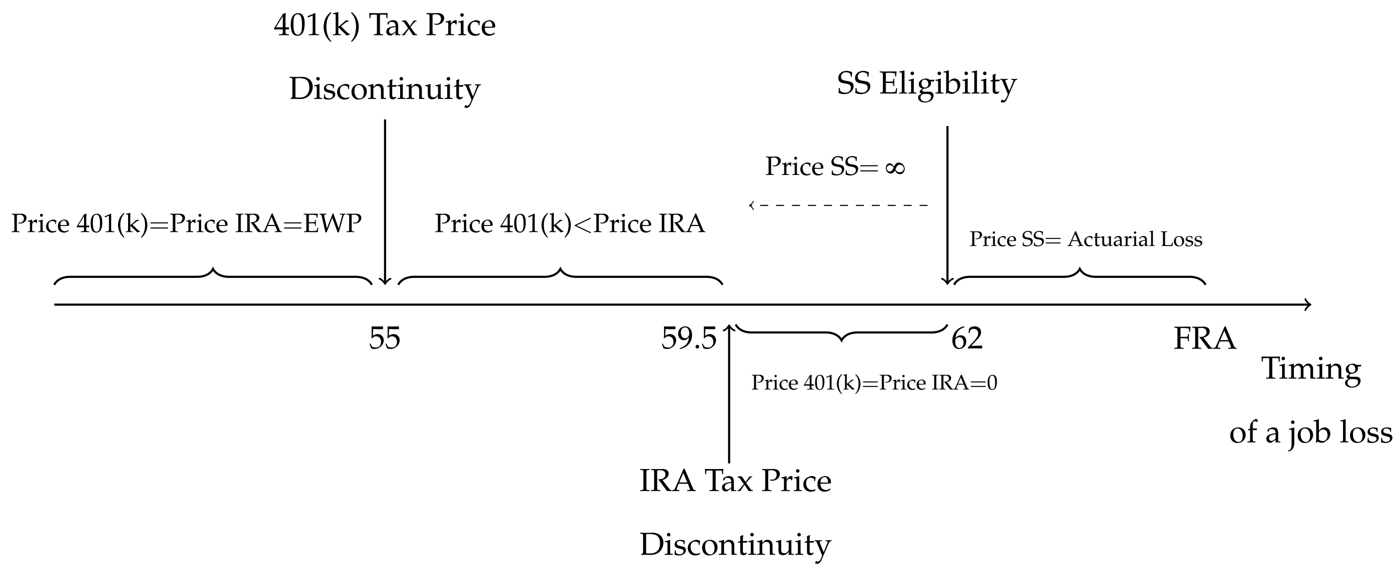
$$V(D_t) = \max_{D_t} \overbrace{u(I_t + D_t(1 - EWP(Age_t)) + UI_t)}^{During\ Unemployment} + \beta \overbrace{u(I_{t+1} + (P - D_t)(1 + r_t))}^{Post\ Retirement} \tag{1.1}$$

The utility of consumption in the pre-retirement period is a function of income I_t, in addition to a pre-retirement pension distribution D_t subject to an age-dependent early withdrawal penalty EWP, as well as unemployment benefits UI_t. After retirement, the early distribution translates to a loss of investment returns on the amount of the distribution $r_t D_t$ where r_t is the rate of return on pension assets. The remaining pension income available to the worker is given by $(P - D_t)(1 + r_t)$. I_{t+1} denotes other sources of post-retirement income such as SS.

A job loss interrupts workers' incomes (reduces I_t) and increases the marginal value of pre-retirement pension distributions. Among the unemployed, the removal of the EWP reduces the tax price of a distribution and thus increases its utility value. The tax price of accessing each of these pensions is age-dependent and is key in determining the order at which older workers make use of these funds in response to layoffs.[7] Three tax price discontinuities influence the drawdown of retirement wealth following a late-career job loss. First, age 55 defines a discontinuity in the tax price of 401(k) funds. A job loss after 55 allows penalty-free access to 401(k)s. Second, age $59\frac{1}{2}$ defines a discontinuity in the tax price of IRAs. After $59\frac{1}{2}$, tapping IRAs becomes relatively cheaper than before $59\frac{1}{2}$. Third, reaching age 62 triggers eligibility for early, but actuarially reduced, SS benefits.

7. For Social Security, the loss at the post retirement period would be the actuarial adjustment resulting from early claiming, leading to a lower stream of SS income.

Accordingly, SS wealth could be seen as a pension account with an infinity tax price of accessing prior to age 62. At age 62, the tax price of claiming becomes equal to the actuarial reduction of the benefits amount relative to claiming at the FRA, 65. Therefore, the timing of the unemployment shock implies the relative tax prices of tapping each of the three available pension accounts.



<u>*Age-dependent tax prices of tapping available pension accounts:*</u> *This diagram illustrates the relative tax prices of tapping of different pension accounts. Prior to age 55, withdrawals from both 401(k)s and IRAs are subjected to a 10% EWP. Within the age range 55-59$\frac{1}{2}$, unemployment-motivated access to 401(k)s is penalty-free but IRAs are still subject to the EWP. After 59$\frac{1}{2}$, the EWP on IRAs is removed. Reaching age 62 unlocks SS wealth. However, claiming prior to the FRA entails an actuarial loss.*

Being a cheaper substitute, UI unambiguously reduces the marginal value of pre-retirement pension distributions. By enabling older unemployed workers to preserve their pension savings from depletion following a job loss, unemployment benefits boosts lifetime and retirement income. The gains in retirement income are the investment returns on the assets that preserved from depletion due to unemployment benefits. The analyses conducted in this paper provides an empirical estimate of the effect of UI on pre-retirement pension withdrawals. Knowing the prevailing average market returns, this estimate can be used to infer the loss of retirement income due to early distributions. A similar rationale applies to social security delays. Unemployment benefits lower the marginal value of early social security benefits. Accordingly, it can keep older unemployed workers from early social security benefit initiation. The return on this delay is lifetime higher amount of benefits realized by claiming later.

1.4 Data

1.4.1 401(k) and IRA asset data

I use data on individual asset holdings in 401(k)'s and IRAs from two consecutive panels from the Survey of Income and Program Participation (the 1996 and 2001 panels), covering the periods 1996-1999 and 2001-2003 respectively. Asset data are collected annually and made available by topical modules accompanying waves 3, 6, 9 and 12 (where available).[8] This data replicate the main features of the age profile and distribution of TDAs' balances known in the literature. Specifically, the effects of age-specific tax rules reflect clearly on the age profile of 401(k) and IRA asset holdings. First, 401(k)'s population average balances start declining significantly exactly after the $59\frac{1}{2}$ age cutoff [Figure 1.1 (A)], corresponding to the removal of the EWP. Figure 1.1 (B) shows a sharp step decline in 401(k) balances' average growth rate immediately at this age cutoff, consistent with the removal of the EWP triggering significant withdrawals immediately after the age $59\frac{1}{2}$. Second, a similar decline in IRA asset holdings is observed after the age of 70,

8. The 1996 Panel provides Asset Data in four topical modules covering individual asset holdings approximately at the end of 1996, 97, 98 and 99. The 2001 panel provides three asset modules at the end of 2001, 2002 and 2003.

consistent with Required Minimum Distributions (RMD) rules triggering withdrawals at the age of $70\frac{1}{2}$ [Brown, Poterba, and Richardson 2017; Love and Smith 2007; Mortenson, Schramm, and Whitten 2019]. Third, being employer-sponsored, 401(k) balances are in line with the age profile of earnings while IRAs remain used throughout retirement transitions.

[Figures 1.1 (A) and 1.1 (B) about here]

Fourth, Appendix Table A.1 shows that the TDAs' asset distribution is highly unequal, consistent with the literature on inequality and the distribution of wealth [Benhabib and Bisin 2018] and the distribution of TDA wealth in particular [Gelber 2011]. The sample at hand contains a total of 287,623 individual-year observations corresponding to 104,031 working-age individuals (22-65 years old). Only 28.2% of these individuals report owning 401(k) accounts, consistent with the low participation rates in employer-sponsored plans documented by Butrica and Smith (2012).[9] Similarly, 19.4% report ownership of an IRA. Consistently, the median values for asset holdings in 401(k)s and IRAs are zeros while the average market values are $7828.2 and $4890.5 ($2000 dollars) for 401(k) and IRA accounts respectively. TDAs asset holdings grow steadily as workers age. However, inequality in retirement savings persists. For the near-retirement population aged 50-59, the median values of 401(k) and IRA accounts are also zeros while the averages are $13,393.8 and $9,526.8 ($2000 dollars) respectively.

[Table 2.8 about here]

1.4.2 Labor market history and demographic characteristics

SIPP allows researchers to link asset data (including assets held in retirement accounts) provided by its topical modules with individuals' detailed labor market histories provided by the core modules of SIPP. Core modules collect information on individuals'

9. Participation rate in employer-sponsored dc plans increased over time reaching about 41% in 2010 [Butrica and Smith (2012)].

weekly labor force status. Each consecutive set of three cores waves of SIPP 1-3, 4-6, 7-9 and 10-12 (where available) cover approximately a calendar year. I compute the total duration (weeks of unemployment) of all unemployment spells experienced by each individual within each of these sets, corresponding approximately to each calendar year. Asset data are collected also approximately at the end of the calendar year. Accordingly, the joint employment-asset dataset I construct includes labor market information throughout the year linked with asset data collected at the end of the year.[10]

To measure the periods of unemployment, I consider the weeks at which workers report being on layoff or absent without pay or without a job and looking for work.[11] For each worker in each year, I compute the number of weeks of unemployment. I then define two indicator variables: 1) being on layoff, $Layoff_{it}$, that equals one if worker i had some weeks of unemployment during year t and zero otherwise, and 2) similar to Chetty (2008), I define the timing of a job loss, $Job\,Loss_{it}$, to be the timing of the transition from an employment to an unemployment state. Accordingly, $Job\,Loss_{it}$ equals one if worker i experienced some weeks of unemployment, due to a layoff, at year t, no weeks of layoff at year t-1 and was not out of the labor force.[12] Accordingly, $Job\,Loss_{it}$ indicates the exact timing (Age-Year) of a job loss. For the population aged 50-59 years old, I identify 1,476 events of job loss for a population size of 22,975 individuals. Workers are observed for four consecutive years in SIPP panel 1996 or for three consecutive years in SIPP panel 2001.

Demographic characteristics of the near-retirement sample approximately match documented U.S. population averages for similar age categories as reported by the 2000 Census. This includes the distributions of educational attainment, race, martial status, and

10. See Appendix for a detailed description of the construction of the dataset.

11. I use the SIPP variables RWKESR1, RWKESR2, RWKESR3, RWKESR4 and RWKESR5 that report worker's labor force status for each week within each month of the panel. I consider a week to be a week of layoff if the worker responded by either *With job/bus - on layoff, absent w/out pay* or *No job/bus - looking for work or on layoff*.

12. I consider an individual to be not in the labor force if he /she reports being unemployed but not looking for a job during all weeks of the year.

gender. About 15.8% of the sample have less than a high school diploma, 31.9% are high school graduates, and 25.9% have a bachelor's degree or higher, which approximately replicates the same distribution of educational attainment for a similar age category in 2000.[13] About 68.5% of the sample are married, and about the 52.5% of sample are women corresponding approximately to the sex ratio among that age category at year 2000.[14]

[Table 1.2 about here]

1.4.3 Social security benefits receipt

SIPP does not provide information on workers' SS claiming age. I identify the timing of SS benefits initiation as the transition from zero to some positive SS income at the annual level. To make sure this approach matches the claiming behavior documented in the literature, I further use the sequence of reported monthly SS income and define a SS claiming event as a sequence of zero monthly SS income followed by some positive monthly SS income. I then truncate the exact age of claiming to the smallest integer value. While this approach might overlook the individuals who, at the onset of the panel, were already SS recipients, I am able to replicate, in Appendix Figure A.1, approximately the same pattern of SS claiming documented using administrative datasets [Munnell and Chen 2015]. I identify 3,133 events of SS benefits claiming for individuals in the 62-70 age range, with a spike in claiming by workers between their 62nd and 63rd birthdays (39.67%), a smaller spike at the FRA (16.34%), 65 for these cohorts and very few individuals waiting beyond the FRA.[15] Consistent with Munnell and Chen (2015), women are less likely to delay claiming till the FRA.

13. Almost similar population averages educational attainment could be obtained using the Census Statistics for similar age categories in 2000. https://www.census.gov/topics/education/educational-attainment/data/tables.2000.html

14. I compare all educational and demographic characteristics of the sample with the relevant statistics provided by the U.S. 2000's census to ensure that the sample at hand approximately matches the same average characteristics for similar age categories in the United States in 2000.

15. I exclude events of claiming whenever disability is reported as a reason for claiming.

1.4.4 State Unemployment Benefit Generosity

Unemployment insurance is a joint federal-state program that provides cash benefits to unemployed workers who lost their jobs through no fault of their own provided that they are able and available to work and are actively seeking re-employment during the benefits' duration. The heterogeneity in state UI benefit generosity stems from the fact that states independently set their own UI benefit formulae.[16] Similar to Agrawal and Matsa (2013) and Hsu, Matsa, and Melzer (2018), I measure regular state UI benefit generosity using the legal parameters defining the maximum generosity of state UI laws; specifically the upper bound of weekly benefits and the maximum duration of eligibility in weeks.[17] I use the product of these two parameters, $Max\,Benefit_{st}$, as a measure of the maximum amount of benefits made available by states' UI regular benefits programs in each year over the period of the SIPP panels used 1996-1999 and 2001-2003. This product reflects the maximum amount of UI benefits a claimant could receive during the course of an unemployment spell. There is limited variation between states and over time in the duration of benefit eligibility (26 weeks on average). However, there is a wide range of variation in the maximum weekly level of income support states make available to the unemployed varying from a minimum of $175 weekly benefits in Missouri in 1996 and 1997, to a maximum of $768 in Massachusetts in 2002. Table 1.3 provides summary statistics on $Max\,Benefit_{st}$ for the 46 states covered by the analyses in this paper.[18] UI is expressed in $1,000 corresponding to 0.38 standard deviation in the maximum amount of benefits available during the course of an unemployment spell in the 46 states and the period of study 1996-1999 and 2001-2003. A variation of $1,000 in benefits is also slightly

16. Additionally, exceptional federal programs might kick in to provide supplemental funding to states during economic downturns. These exceptional programs include the Extended Benefits Program and the Emergency Unemployment Compensation Program. However, the analyses carried out in this paper all focus on the states' regular UI programs.

17. These UI generosity parameters are collected from the U.S. Department of Labor webpage on the '*Significant Provisions of State UI Laws*' and are made available by Hsu, Matsa, and Melzer (2018).

18. To ensure respondents' confidentiality, SIPP data provides state location information only for respondents residing in 45 states and the District of Columbia. Omitted states are Maine, Vermont, North Dakota, South Dakota and Wyoming.

less than half the average state-level change in unemployment benefits over the period of the study.

[Table 1.3 about here]

The generosity of these benefits also changed considerably over time, with an average increase of 31% or $2210 in 2003 relative to 1996. Figure 1.2 shows the geographic distribution of these state UI changes by quartiles. I do not detect a clear geographic pattern of these percentage changes. For instance, states with highest increases in their benefits include Northeastern states such as Massachusetts with a 46% increase, Southern states such as Georgia with a 44% increase, Midwestern states such as Missouri with a 43% increase, and Western states with a 61% increase.

[Figure 1.2 about here]

1.5 Late-career job loss and pension asset decumulation

1.5.1 Late-career job loss and 401(k) pension decumulation

I start with an empirical estimation of the effect of a job loss, around age 55, on 401(k) savings. The cost of accessing 401(k) funds following a layoff depends on the age at which workers separate from service. By waiving the EWP at age 55, the tax code exception creates a sharp discontinuity in the tax price of accessing these funds for laid-off workers, whereas the EWP remains effective for non-job losers.[19] Accordingly, unemployed workers' incentives to tap their 401(k)s vary sharply depending on the age at which they lost their jobs, pre vs. post age 55. I graphically illustrate the effect of this discontinuity on the pattern of 401(k) asset accumulation of job losers. I use the job loss timing measure $Job\,Loss_{it}$ to plot, in Figure 1.3, the age profile of average 401(k) asset growth rates for two

19. The EWP is then completely removed for all groups at age $59\frac{1}{2}$.

groups: workers who separated from service due to a layoff and all other individuals. I average workers' asset growth rates for each of these two categories by age, net of person fixed-effects (subtracting the average growth rate for each worker). I provide an overview of the sample sizes, by age and employment status, involved in graphing this figure in Table 1.4. For the near-retirement population, age 50-59, I identify 1,476 layoff events. Among these, 323 layoff events correspond to individuals owning 401(k) accounts. The 401(k) ownership rate among the whole population age 50-59 is 30.5%. Job separation rates for this near-retirement sample of individuals reflect the U.S. population average unemployment for approximately the same age categories during the period 1996-2003.[20]

[Table 1.4 about here]

The treatment group line (blue line in Figure 1.3) depicts job losers' average growth rates of assets held in 401(k) accounts by age of job loss. The control group (red line on the same figure) plots the average 401(k) asset growth rates of non-job losers. While accessing 401(k) becomes less costly for those who got laid-off after age 55 compared to those who lost their jobs prior to age 55, the tax price is constant for non-job losers. Consistently, Figure 1.3 shows a divergence of savings' trends between the two groups starting exactly at age 55. Specifically, it documents a precipitous decumulation of 401(k) assets for individuals who experienced a layoff after age 55 compared to those who experienced one prior to that age, relative to the individuals who did not experience a layoff. For workers younger than 55, the two trend lines, net off fixed-effects, are almost identical. This post-age 55 decumulation of 401(k) assets and the identical pre-age 55 trends suggest a causal effect of the change in the tax price of accessing 401(k)s by job losers.

[Figure 1.3 about here]

20. The quarterly unemployment rate for the population aged 55-64 years old during 1996-2003 is around 3-3.5% as provided by the BLS at https://data.bls.gov/PDQWeb/ln. and approximately similar to the rates implied by the separations documented in Table 1.4.

To provide an average estimate of the effect a job loss after age 55 compared to before 55, I estimate the following specification for the population aged 50-59 years old:

$$Y_{it} = \alpha + \eta_i + \beta_1 \, Job\,Loss_{it} + \beta_2 \, \mathbb{1}[Age_{it} > 55] + \beta_3 \, \mathbb{1}[Age_{it} > 55] \times Job\,Loss_{it} + \zeta_{st} + \mathrm{X}_{it}\Gamma + \epsilon_{it} \quad (1.2)$$

The dependent variable $Y_{it} = ln(A_{it} + 10) - ln(A_{it-1} + 10)$ is the annual growth rate of 401(k) assets A_{it} of worker i of age Age_{it} at year t, holding the average asset growth rate $(\overline{ln(A_{it} + 10) - ln(A_{it-1} + 10)})$ for each worker constant, by accounting for person fixed-effects η_i.[21] $Job\,Loss_{it}$ is equal to one if worker i got laid-off at year t and zero otherwise. $\mathbb{1}[Age_{it} > 55]$ is an indicator function that equals one if the worker is older than 55 at the end of calendar year t and zero otherwise. ζ_{st} holds state-wide policies and shocks constant; X_{it} is a vector of person-specific time-varying controls accounting for lagged versions of earnings, financial assets and liabilities owed independently and jointly with spouse;[22] α is an intercept term and ϵ_{it} is an idiosyncratic error term. Accordingly, β_1 quantifies the average association between job loss and the growth rate of 401(k) savings and β_2 captures the average difference between workers older and younger than 55. The coefficient of interest β_3 quantifies the average effect of a layoff after age 55 compared to a layoff before 55 on the growth rate of 401(k) pension savings. Consistent with the effect illustrated in Figure 1.3, Table 1.5 [Column (1)] displays the estimates for β_3. A job loss just after the age 55 results in a 51 percent larger decline in 401(k) pension savings compared to a job loss just before 55, corresponding to a job loss motivated withdrawal of approximately $5,900 (in 2000's dollars) of pension assets.

[Table 1.5 about here]

21. Similar to Gelber (2011), 401(k) assets are incremented by $10 so that the natural logarithm is defined for all asset observations including workers having zero assets.

22. X_{it} includes annual earnings, checking and saving accounts' balances, bonds and stock holdings, credit card debt and store bills owed (independently and jointly with spouse) and mortgage or rent payments. These control variables account for households' balance sheets and reflect the flexibility they have in weathering unemployment shocks.

To test for functional form dependence, I use an alternative transformation for the dependent variable, 401(k) assets. Similar to Gelber (2011), I use the Inverse Hyperbolic Sine IHS transformation suggested by Burbidge, Magee, and Robb (1988). The IHS is an alternative transformation that suits the distributional aspects of wealth data. It reduces the influence of extreme values of wealth and is defined for zero values and thus, can handle the excess observations of zero wealth.[23] I estimate specification 1.2 with the dependent variable being $[Sinh^{-1}(A_{it}) - Sinh^{-1}(A_{i(t-1)})]$. Using this transformation, I report in Table 1.5 [Columns (2)] an estimate within the same range estimated earlier.

These results suggest that the depletion of TDAs upon job loss is highly sensitive to the tax price of accessing retirement accounts. An unemployment shock is 51% more damaging to 401(k) wealth in a penalty-free setting (post-55) compared to a setting where withdrawals are penalized by a 10% tax. The policy importance of this findings emanates from the current usage of the EWP as a policy lever to alleviate financial hardships. For instance, in light of the current labor market downturn, the CARES act waived the EWP for coronavirus-related distributions with a view to reduce the cost of resorting to 401(k) savings during unemployment.[24] While it can alleviate unemployment-related hardships, the removal of the EWP can lead to a depletion of retirement savings with significant consequences for retirement income adequacy, specifically for workers with a history of unemployment shocks.

These results serve as guidance for policymakers considering the option to use the early withdrawal penalty as a policy lever in response to similar future economic downturns.[25] Additionally, the US pension system is highly in favor of a more flexible pension system with relatively low cost of accessing pension savings compared to other devel-

23. The IHS is defined as $Sinh^{-1}(A_i) = \ln(A_i + \sqrt{1 + A_i^2})$.

24. CARES act waives the EWP on coronavirus-related distributions including for being diagnosed with COVID-19 of for labor market shocks resulting from COVID-19. To be considered eligible to this waiver, workers are asked to self-certify that they meet an eligibility requirement is based on self-certification. https://www.tiaa.org/public/learn/prepare-unexpected/guiding-you-through-turbulent-times/cares-act#20001002080502

25. Other countries have also adopted an income-contingent pre-retirement withdrawal penalty [Beshears et al. 2015].

oped economies [Beshears et al. 2015]. However, such preference for liquidity imposes a trade-off between the benefits of being able to respond to pre-retirement job losses on one hand and the depletion of retirement savings that might result from that flexibility on the other hand. Accordingly, the estimates provided in Table 1.5 contribute to the debate on the optimal liquidity of the pension system in the US.

1.5.2 Density analysis

The identifying assumption in this analysis is that a job loss immediately after the age threshold 55 is not associated with unobservable factors influencing pension withdrawals, compared to a job loss just before 55. A potential threat to this analysis is the probability of manipulation of the running variable; the timing of the layoff in this case. This could be the case if employers and older workers jointly manipulate layoffs' timings to provide workers with the option to cash-out their 401(k)'s penalty-free to help them weather the shock of the layoff. Two main factors seriously weaken the credibility of this threat. First, such manipulation would be costly for firms as it requires them to keep workers, that would otherwise be laid-off, on their payrolls for additional time until they reach the age threshold. Second, being costly for firms, such age-targeting layoff strategy could only be implemented with workers that are very close to turning 55 which seriously limits the potential and the feasibility of such strategy. However, if, hypothetically, this manipulation of layoffs' timings is prevalent, the 401(k) pension asset outflows documented in Figure 1.3 and Table 1.5 could reflect the effect of policy-induced job separations and their related 401(k) distributions, as opposed to the liquidity constrained motives documented in this paper. In light of McCrary (2008), if this discontinuity in the tax-price of accessing 401(k) funds induces strategic job separations at age 55, it would reflect as a discontinuity in the likelihood of observing a job loss around the age cutoff 55. To test this hypothesis, I estimate the likelihood of observing a job separation due to a layoff at each age within the age range 50-59 using the following linear probability model:

$$Job\,Loss_{iAget} = \alpha + \sum_{A \neq 54} \mathbb{1}[Age_{it} = A] \times D_A + \gamma_t + \epsilon_{iAget} \tag{1.3}$$

$Job\,Loss_{iAget}$ is an indicator function that equals one at the timing of a job loss for individual i aged Age_{it} at year t and zero otherwise. γ_t denotes year fixed-effects. ϵ_{iAget} is an idiosyncratic error term. Each coefficient D_A quantifies the likelihood of observing a job loss for employees aged A at year t, relative to an omitted category (age 54). Appendix Figure A.2 plots the set of estimated coefficients $\hat{D}_A$'s, showing no evidence of a discontinuity in the likelihood of observing a layoff at the cutoff age or at any age within the age range in question. The almost flat pattern on the $\hat{D}_A$'s significantly lessens the concerns about policy-induced job separations at age 55.

1.5.3 Late-career job loss and IRA funds

Conducting a similar analysis for assets held in IRA accounts serves three purposes. First, were these flows out of 401(k) pensions *rolled over* into IRAs?[26] If yes, the observed decumulation of 401(k) assets after age 55 would reflect a movement of funds between different TDAs, rather than an unemployment-induced leakage of pension assets towards non-retirement purposes. To address this possibility, I re-estimate specification 1.2 using the growth rates of IRA assets as a dependent variable. The economically and statistically insignificant estimate of β_3 provided in table 1.5 [Column (3)] indicates that IRA assets do not react differently in response to a job loss after 55 compared to one prior to 55. Hence, the decumulation of 401(k) assets following a post-55 layoff is not accompanied by an increase in IRA assets, which rules out the rollover hypothesis consistent with a leakage of retirement funds out of the tax-deferred pension system.

26. The term *rollover* describes the transfer of funds between 401(k) and IRA accounts. *Rollovers* preserve the tax-deferred status of the funds as opposed to a leakage of funds out of the tax-deferred pension system.

Second, since IRAs are not eligible for a similar suspension of the EWP in the event of a separation from service after age 55, the tax price of accessing IRA funds for job losers remains constant around that age. Accordingly, the economically and statistically insignificant response of IRA funds, estimated by $\hat{\beta}_3$, serves as a placebo test supporting the results on 401(k) outflows.

Third, at age $59\frac{1}{2}$, there is a similar discontinuity in the tax price of accessing IRA funds. In fact, the EWP is completely removed regardless of employment status starting that age. Appendix Figure A.3 provides a graphical illustration of the evolution of mean IRA asset growth rates, net of fixed effects, among job losers and all other individuals by age. I document a similar response of IRA asset growth rates of job losers immediately following the removal of the EWP. Specifically, a job loss immediately after $59\frac{1}{2}$ triggers a large and precipitous decumulation of IRA funds compared to a job loss prior to $59\frac{1}{2}$.[27] This result provides an additional piece of evidence on the effect of the removal of the EWP on job loss-motivated withdrawal of pension assets.

1.6 UI as a substitute for private pension withdrawals

What role UI can play to mitigate the effects of late-career shocks on private pension decumulation? By alleviating the income shocks resulting from job losses, generous unemployment benefits can reduce the marginal value of unemployment-motivated 401(k) pension withdrawals relative to the value of keeping these funds within the tax-deferred pension system (including the investment returns and tax benefits). Accordingly, I test the hypothesis that the more generous state unemployment benefits, the less the 401(k) pension withdrawals made by older unemployed workers. To test this hypothesis, I estimate

27. Since I use integer values of age, the precipitous decumulation of IRA assets is observed exactly at age 61 (See Appendix Figure A.3).

the following specification for the near-retirement population age 50-59:

$$Y_{ist} = \alpha + \beta_1 \; On \; Layoff_{it} + \beta_2 \; On \; Layoff_{it} \times Max \; Benefit_{st} + \eta_i + \zeta_{st} + X_{it}\Gamma + \epsilon_{ist} \tag{1.4}$$

Similar to specification 1.2, the dependent variable is the annual growth rate of 401(k) assets for worker i residing at state s at year t, holding the average asset growth rate for each individual constant by accounting for person fixed-effects η_i. $Layoff_{it}$ is an indicator function that equals one if individual i had some weeks of layoff at year t and zero otherwise. $Layoff_{it}$ is interacted with $Max\ Benefit_{st}$, the maximum dollar amount of unemployment benefits provided by state s at year t during the course of an unemployment spell (in \$1000 of benefits), computed as the product of the maximum weekly benefits and the duration of benefits eligibility in weeks. $Max\ Benefit_{st}$ is demeaned relative to the average of the 46 states included in this analysis presented in Table 1.3. ζ_{st} holds state-wide policies and shocks constant; X_{it} is a vector of person-specific time-varying controls accounting for lagged versions of earnings, financial assets and liabilities owed independently and jointly with spouse; α is an intercept term and ϵ_{ist} is an idiosyncratic error term.

Accordingly, β_1 is an average association between being on layoff and 401(k) pension savings rate. Among the unemployed, the coefficient of interest β_2 quantifies the effect of UI generosity on the flows of 401(k) savings, holding other state-wide policies and shocks constant. Table 1.6 (column 1) shows that being on layoff is associated with 18.5% less 401(k) asset growth in the state with the average level of UI generosity. Most importantly, the coefficient estimate $\hat{\beta}_2$ shows that a \$1000 increase in the upper bound of the total state UI benefits, during the course of an unemployment spell, increases 401(k) asset accumulation by 7%. This estimated effect of an additional \$1,000 of unemployment benefits corresponds to helping older unemployed workers preserve an average of about \$750 of 401(k) pension savings from flowing out of workers' pension accounts during unemployment spells.[28] In the sample of states at hand (46 states during the periods 1996-1999 and 2001-2003), a one standard deviation change in maximum state unemployment benefits during the course of an unemployment spell, corresponding to $2,610, helps older unemployed workers preserve approximately $1,950 of 401(k) pension assets.

[Table 1.6 about here]

Multiple arguments support a causal interpretation of this finding. Controlling for state-year fixed effects absorb all (observed and unobserved) state-by-year variations, including state economic or policy shocks. Additionally, using an alternative specification that does not account for state-year fixed effects, I estimate the effect of UI generosity on individuals without a layoff in [Table 1.6: Column (2)]. Using this specification, I show that $Max\,Benefit_{st}$ has an insignificant average effect except on the unemployed. While employed workers' savings can be affected by UI through a precautionary motive channel [Engen and Gruber 2001], UI is expected to have a much more pronounced effect on the primarily targeted population of the unemployed. Accordingly, the small magnitude and the insignificance of the estimate of the coefficient on $Max\,Benefit_{st}$ serves as a falsification test. Specifically, it indicates that state UI benefit generosity has no meaningful association with the pension savings of the employed population who are ineligible for UI.[29]

UI crowds out the need for pre-retirement 401(k) asset withdrawals. By preserving these assets from depletion, UI boosts lifetime income and specifically, retirement income. This increase in income is equal to the returns on these preserved assets and the tax advantages should these withdrawals be delayed. For instance, the geometric rate of nominal return on defined contribution plans over 1990-2012 is in the range of 5.9-7.6% depending

28. This amount is the difference in the flow of assets out of 401(k) accounts among unemployed individuals having access to unemployment benefits of different generosity. Additionally, this flow of funds measure also translates to an equivalent difference in the stock of pension assets among the unemployed based on the state UI generosity.

29. To avoid selection into treatment, I also remove a very limited of observations corresponding to workers who moved between states.

on plan size [Munnell, Aubry, Crawford, et al. 2015]. Accordingly, the average financial return of preserving $750, due to a $1000 increase in maximum state UI generosity, is in the range of $44-$57 per year of delay.

1.6.1 Interaction with precautionary non-tax-deferred savings

In addition to social insurance, jobless workers can also draw down their non-retirement assets to smooth their consumption during unemployment spells. Using assets held outside of retirement accounts for consumption smoothing could be a less costly option compared to 401(k) withdrawals. Resorting to non-tax-deferred assets instead of 401(k)s can help unemployed workers avoid the EWP and the income tax liabilities arising from pension withdrawals. In this context, assets held outside of retirement accounts also reduces the marginal value of early 401(k) withdrawals. Workers with ample financial wealth held outside of TDAs are less likely to resort to the more costly option of tapping their pension accounts during unemployment. Accordingly, I make the hypothesis that the effect of UI on pension withdrawals is likely to be smaller for workers with ample non-tax-deferred wealth to rely on during unemployment and vice versa.

To this hypothesis, I allow for UI to have heterogeneous effects based on the availability of non-retirement precautionary wealth. I interact the amount of liquid financial wealth held outside of retirement accounts immediately prior to the unemployment period, with state UI benefit generosity and layoff status. This includes assets held in checking and saving accounts, bonds, stocks, and funds held in own name and those held jointly with spouse. Consistent with non-retirement wealth being a cheaper substitute for pre-retirement pension withdrawals, the negative value of the coefficient estimate on $Max\, Benefits \times On\ Layoff \times Liquid\, Assets$ indicates that UI generosity has a smaller effect on those with ample non-retirement wealth. Conversely, increases in unemployment benefits reduce 401(k) pension withdrawals more for the most liquidity-constrained workers; those with few assets held outside of retirement accounts. While UI does crowd out the need for 401(k) pension withdrawals for more than 95% of the population, UI produces has almost zero effect on retirement savings of workers owning $100,000 of non-tax-deferred assets, consistent with UI being more influential for liquidity constrained workers.

[Table 1.7 about here]

While the availability of precautionary non-TDA savings can shield pension wealth, Lusardi, Mitchell, and Oggero (2020) show that more recent cohorts of near-retirement individuals hold more debt and less liquid assets compared to previous similarly aged cohorts. Accordingly, the effect of UI is likely to become more influential as cohorts of older workers become more financially fragile over time.

1.6.2 Factors influencing external validity

Further research is needed to test these findings in the context of the current COVID-19 recession. The CARES act relief measures included both a suspension of the early withdrawal penalty and an extension of unemployment benefits. The evidence provided by this paper helps understand the effects of these two policies on older unemployed workers' retirement savings. However, for the current recession, two additional factors may be considered. First, the economic contraction resulting from the current pandemic is much stronger than the normal recessions during the period of the study 1996-1999 and 2001-2003. Second, older workers are particularly vulnerable to the health risks of the pandemic. Accordingly, the health risks of taking a job could increase the utility of remaining unemployed. Employers might also further discriminate against older workers to avoid potential liabilities or reputational damage about the safety of the work environment they maintain. Additionally, if older individuals get sick, their ability to search for a job can be reduced. These factors suggest that older unemployed workers could face longer unemployment durations and smaller chances of re-employment. While the liquidity constraints arising from longer unemployment periods could actually intensify pension asset withdrawals, higher unemployment benefits could still reduce this leakage of retirement funds, particularly given the recent extensions. However, loosing a job during a severe contraction, such the COVID-19 one, significantly raises search costs and post-displacement wage reductions [Merkurieva 2019]. These effects may discourage job search leading to longer term unemployment, particularly for older workers. Accordingly, UI, being a short term measure limited by a maximum duration of eligibility would not be a sufficient policy response to prevent leakage from retirement accounts in such prolonged recessionary periods.

1.7 UI as a substitute for early social security benefits

Next, I test the hypothesis that more generous state UI benefits incentivize older job losers to delay SS benefit claiming. The channel of this effect is similar to the effect of UI on pre-retirement 401(k) pension withdrawals. An increase in unemployment benefits reduces the marginal value of early SS income relative to the actuarial gains of delaying the claiming decision. Similar to avoiding 401(k) asset withdrawals, the decision to delay SS benefits also has a financial return. Delaying claiming increments the benefit amount by approximately 6.67% of the worker's primary insurance amount for each year of benefits delay (or $\frac{5}{9}\%$ per month).[30]

To test this hypothesis, I compare the likelihood of early (pre-65) SS benefit initiation by older workers subjected to job loss shocks at different ages and residing in states having different levels of UI benefit generosity at different points of time. Accordingly, I estimate the effect of job loss and of state unemployment benefit generosity on subsequent SS benefit initiation by job losers. I estimate the following regression specification

30. The penalty of early claiming increased over time. For cohorts born in 1937 or earlier, the penalty of claiming at 62 is 20% of the PIA. The penalty of claiming at 62 increased to 25% of the PIA for cohorts born between 1943-1954 and 30% for cohorts born on 1960 or later.

separately for workers of age 61, 62, 63 and 64:

$$Pr[SS\,income_{t+1} > 0 \mid SS\,income_t = 0]_{ist_{Age}} = \alpha_{A_{ge}} + \beta_{1_{Age}}\,Job\,Loss_{it} + \beta_{2_{Age}}\,Job\,Loss_{it} \times Max\,Benefit_{st} + \zeta_{st} + X_{it}\Gamma + \epsilon_{ist};\;\; Age = 61, 62, 63\; and\; 64 \tag{1.5}$$

The dependent variable is a binary variable that equals one if individual i residing at state s reports some social security income at t+1 and zero otherwise, conditional on reporting no social security income at t. Accordingly, a value of zero indicates delaying SS claiming for at least one year. $Job\,Loss_{it}$ is equal to one if worker i experienced a job loss at year t and zero otherwise. $Max\,Benefit_{st}$ is the maximum amount of unemployment benefits provided by state s at year t (expressed in \$1000 and demeaned relative to the average of the 46 states). ζ_{st} holds other state-wide policies and shocks constant. X_{it} is a vector of person-specific controls, ϵ_{ist} is an idiosyncratic error term and α is an intercept term. Among workers of a given age, $\beta_{1_{Age}}$ is the average propensity to initiate social security benefits at t+1 in response to a job loss occurring at t compared to a non-job loser in the state with the average generosity of unemployment benefits. Among job losers, $\beta_{2_{Age}}$ quantifies the average differential response between job losers having access to UI systems of different generosity to an additional \$1000 of maximum state UI benefits.[31]

I estimate this regression separately for workers of age 61, 62, 63 and 64. The set of estimated $\hat{\beta}_{1_{Age}}$'s in Table 1.8 show that following a late career job loss, job losers have a higher average propensity to immediately initiate their stream of social security benefits. The set of coefficients' estimates $\hat{\beta}_{2_{Age}}$'s address the research question and the contribution of this paper; specifically whether UI benefit generosity can reduce job loss-motivated early SS benefits claiming and lead workers to opt for a higher benefit amount by claiming later. For instance, $\hat{\beta}_{1_{61}}$ shows that following a job loss at age 61, job losers are 26% more likely than non-job losers to initiate their social security stream of benefits immediately

31. I remove a very limited number of observations corresponding to workers who moved between states, as well as those who ever reported disability as a reason for claiming social security.

after at 62 in the state with the average generosity of state unemployment benefits. However, $\hat{\beta}_{2_{61}}$ shows that a $1,000 increase in state unemployment benefits reduces this likelihood by 4.5 percentage points. Accordingly, a $5,900 increase in the maximum amount of state unemployment benefits over the course of an unemployment spell can fully reduce the average propensity of job losers' early claiming down to the same propensity of early claiming by non-job losers.

Similarly, $\hat{\beta}_{1_{62}}$ shows that workers experiencing a job loss at age 62 are also 24% more likely to have their stream of benefits running the year after at the state with the average level of maximum unemployment benefits. However, $\hat{\beta}_{2_{62}}$ shows that a $1,000 additional maximum state unemployment benefits reduces this likelihood by 9.1 percentage points. Accordingly, a $2,600 increase in maximum state unemployment benefits can make job losers on average not more likely to claim immediately after than non-job losers. A job loss at age 63 produces the same effect with 48% higher likelihood of social security receipt at 64. $\hat{\beta}_{2_{63}}$ reflects a similar economically meaningful effect in reducing this likelihood by 11.6 percentage points but is statistically insignificant (p-value=0.235).

Finally, since both job losers and non-job losers are unlikely to delay benefits claiming beyond the full retirement age 65, estimating specification 1.5 for workers age 64 could serve as a falsification test. For those age 64, the small and statistically insignificant $\hat{\beta}_{1_{64}}$ points to no statistically meaningful difference between job losers and non-job losers claiming at 65, consistent with very few individuals delaying beyond 65 regardless of employment status [Appendix Figure A.1]. Consistently, the economically and statistically insignificant coefficient estimate $\hat{\beta}_{2_{64}}$ indicates that state unemployment benefits provide no incentive for job losers to delay claiming beyond age 65, the SS full retirement age.

[Table 1.8 about here]

1.7.1 Intertemporal considerations

Delaying social security entails forgoing current benefits in exchange for higher future benefits. A one year delay in claiming raises the value of future benefits by 6.67% of the worker's primary insurance amount. A large number of studies emphasize that delaying the claiming decision is financially advantageous for individuals with average life expectancy and particularly for couples [Coile et al. 2002; Maurer et al. 2019; Meyer and Reichenstein 2010; Shoven and Slavov 2014]. However, the exact income and utility gains from a delay are person-specific and depend on subjective mortality expectations, intertemporal elasticity elasticity of substitution, rate of time preference and worker's primary insurance amount. In the appendix, I use conservative assumptions to estimate the resulting increase in the expected present discounted value of the stream of benefits from an optimal delay for a single worker to be 0.62 and 3.34 PIAs for men and women respectively.[32]

However, a job loss raises the marginal value of early SS benefits leading to a pattern of early claiming by job losers in spite of the financial gains from a delay. In contrast, unemployment benefits reduce the marginal value of early SS benefits. As state unemployment benefits increase, more job losers, who would otherwise claim immediately after the job loss, become more likely to delay claiming. Through this analysis, I quantified the additional amount of unemployment benefits that would completely eliminate the average excess propensity of early claiming by job losers compared to non-job losers. Accordingly, by incentivizing job losers to delay claiming, unemployment benefits also raise future social security income leading to a net increase in the expected present discounted value of the resources available to workers for retirement funding.

32. Gains from a delay can be much higher for married couples, particularly through its effects on survivors' benefits [Coile et al. 2002; Meyer and Reichenstein 2010; Shoven and Slavov 2014]

1.8 Conclusions

This paper provides evidence on a fast depletion of pension wealth resulting from late-career unemployment shocks. These depletion decisions are highly sensitive to the tax-price of accessing pension accounts. Most importantly, unemployment insurance alleviates job loss-related income shocks, reduces the marginal value of pre-retirement pension distributions, and leads workers to slow down their pension asset decumulation. A similar mechanism is demonstrated for early Social Security benefits claiming. Unemployment insurance reduces the marginal value of early SS benefits and incentivizes older unemployed workers to delay their SS claiming. UI enables them to avoid the loss of market returns on their 401(k) savings and opt for a higher stream of social security income. These results show that UI increases future retirement income, particularly for individuals with a history of late-career unemployment shocks.

The policy importance of these pension withdrawal decisions emanates from their timing. Pensions assets depleted at a near-retirement stage are less likely to be replaced. Hence, the loss of market returns associated with these pension withdrawals is likely to leave older workers with reduced retirement income and increased vulnerability to later-life poverty. These results have important implications impacting nearly a million older unemployed US workers, age 55-64, who experience generally longer average unemployment duration than their younger peers. Most importantly, these results shed light on an unintended role of unemployment insurance. In addition to its consumption smoothing effect, it slows down pension wealth decumulation for the unemployed, leading to positive long term consequences on their retirement income security.

These results will be even more relevant in light of the recent evidence on the increased financial vulnerability of the near-retirement population including the decline in their savings and the increase in their debt holdings [Brown et al. 2019; Lusardi, Mitchell, and Oggero 2020]. Those with a small buffer stock of non-pension wealth to face an unemployment shock will increasingly resort to retirement savings and early SS benefits claiming. To support this point, I show that the mitigating effect of unemployment benefits on pension asset decumulation is more economically significant for more liquidity constrained workers, those who lack savings outside of retirement accounts.

1.9 Tables and Figures

Table 1.1: Wealth, Retirement Accounts and Earnings for the near-retirement (50-59 years old) Population

	Mean	Median	Std. dev.	Obs.
Near-retirement workers				
IRAs	9,526.8	0	32,839.0	56,649
401(k)	13,393.8	0	40190.1	56,649
Annual Earnings	27,748.0	19,992	36,480.6	56,649
Near-retirement Job Losers				
IRAs	8,686.1	0	33,101.1	1,476
401(k)	11,586.8	0	37,345.0	1,476
Annual Earnings	20,572.3	14,714.6	24,460.1	1,476

	in Own Name			Jointly with spouse		
Asset Type ($)	Mean	Median	Std. dev.	Mean	Median	Std. dev.
Checking Accounts	142.7	0	634.7	149.4	0	508.0
Interest Earning Accounts	3,095.2	0	13,183.4	3,827.5	0	12,131.2
Bonds	1,132.1	0	22,721.5	755.0	0	9,573.2
Stocks and Funds	14,555.9	0	628,571.9	13,781.3	0	646,341.0
Total Liquid Assets	18,928.7	0	634,200.7	18,513.18	0	646,900.1
Credit Card and Store Bills	1,040.6	0	30,534.7	1,106.5	0	24,079.8

Note: This table provides summary statistics of assets held in tax-deferred retirement accounts (reported in own name) and liquid non-tax-deferred assets in addition to credit card and store bills for the sample of 50-59 years old workers. The sample contains 56,649 worker-year observations. Retirement savings, non-retirement wealth and credit card data are obtained from the SIPP topical modules accompanying waves 3,6,9 and 12 (where available). Individuals' annual earnings are obtained by summing the stream of monthly earnings over each year of data. Values are reported in 2000's $.

Table 1.2: Education and Demographic Characteristics for the near-retirement 50-59 year old population

Education	
Less than high school diploma	17.1%
High school diploma	31.9%
Some college, diploma or associate degree	27.7%
Bachelor's degree or higher	25.6%
Race	
White	83.4%
Black	12.2%
Other	4.4%
Gender	
Men	47.5%
Women	52.5%
Marital Status	
Married	70%
Widowed	5.5%
Divorced	18.2%
Separated	3.4%
Never Married	6.5%
Number of Workers	22975

Note: This table provides demographic information for the near-retirement sample, age 50-59 years old. Education and demographic characteristics approximately match the known U.S. population averages for similar age categories in 2000 as provided by the U.S. 2000 decennial census. Source: Author's calculation based on the SIPP sample.

Table 1.3: UI State Benefit Generosity (1996-1999) and (2001-2003)

	State UI Benefits		
	Mean	Median	Std. dev.
Weekly Benefits ($ 1000)	0.31	0.3	0.09
Benefits Duration (Weeks)	26.17	26	0.82
Maximum Benefits ($ 1000)	8.14	7.77	2.61
Increase in Maximum Benefits ($ 1000) over the period 1996-2003	2.21	2.07	1.29
% Increase in Maximum Benefits over the period 1996-2003	32	31	15
Number of States		46	
States-Year		322	

Note: This table provides summary statistics of for the legal parameters defining the generosity of state unemployment benefits through the period of the study (1996-1999) and (2001-2003). Source: Data on the significant provisions of state UI laws are provided by the U.S. Department of Labor and compiled by Hsu, Matsa, and Melzer (2018). Values reported in nominal dollars.

Table 1.4: Sample Size of employed and laid-off workers with 401(k) accounts at each age for the 50-59 years old population

			Sample Size per Age							
Workers of Age:	50	51	52	53	54	55	56	57	58	59
401(k) Account Owners										
Employed 401(k) owners	1900	1775	1622	1531	1469	1331	1148	1049	895	855
Job losers with 401(k)'s	45	43	38	38	33	33	27	14	23	29
All workers including non-401(k) owners										
Employed	6025	5607	5262	4855	4689	4448	4062	3678	3306	3154
Job Losers	210	198	158	172	152	144	128	126	95	101
Job Separation Rate (%)	3.49	3.53	3.00	3.54	3.24	3.24	3.15	3.43	2.87	3.20
Out of the Labor Force	864	899	900	936	994	1023	1056	1111	1136	1226
No. of workers	22975									
Workers with 401(k)s	7013									
401(k) Ownership Rate (%)	30.52									
Layoff Events	1,476									

Note: This table provides the sizes of the two samples used to draw figure 1.3 including employed and laid-off 401(k) account owners at each age within the age range 50-59 years old. 323 job loss events correspond to individuals with 401(k) accounts. Source: Author's calculation based on the SIPP sample.

Table 1.5: Unemployment-motivated 401(k) Pension Asset Withdrawal by the near-retirement population (age 50-59 years old)

	(1) $\Delta\, log\,(401(k) Assets + 10)$	(2) $\Delta\,\text{Sinh}^{-1}(401(k) Assets)$	(3) $\Delta\, log\,(IRA\, Assets + 10)$
$Job\, Loss_{it} \times \mathbb{1}[Age > 55]$	-0.511*	-0.654*	0.0337
	(0.287)	(0.396)	(0.250)
$Job\, Loss_{it}$	-0.0596	-0.132	-0.0796
	(0.142)	(0.195)	(0.115)
1[Age>55]	-0.0433	-0.0782	-0.0148
	(0.0847)	(0.114)	(0.0797)
Person time-varying controls	✓	✓	✓
Person FE	✓	✓	✓
State-Year FE	✓	✓	✓
Worker-Year Observations	32,090	32,090	32,090
Number of Workers	13371	13,371	13,371
R^2	0.286	0.288	0.270

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

Note: This table reports the coefficient estimates for specification 1.2 for the population of age 50-59 years old using two alternative wealth transformations: $\Delta\, log\,(401(k) Assets + 10)$ and $\Delta\; Sinh^{-1}(401(k) Assets)$. The estimate in column (1) shows that a job loss after age 55 leads to a 51 percent larger decline in 401(k) pension savings compared to a job loss prior to age 55. Economically and statistically insignificant response of IRA assets reported in column (3) indicates that flows out of 401(k) pensions were not *rolled over* to IRA accounts, which implies a leakage of retirement savings out of the tax-deferred pension system. Person time-varying controls include lagged versions of other liquid taxable assets held by the worker, earnings, credit card debt, store bills and rent (or mortgage payments). Standard errors are clustered at the worker's level.

Table 1.6: The Mitigating Effects of Unemployment Insurance on 401(k) Asset Decumulation by older unemployed workers (Population age 50-59 years old)

	(1) $\Delta\, log(401(k)Assets + 10)$	(2) $\Delta\, log(401(k)Assets + 10)$
$Max\ Benefits$ (\$1000) $\times\ On\ Layoff$	0.0720***	0.0697***
	(0.0209)	(0.0203)
$On\ Layoff$	-0.184*	-0.194*
	(0.100)	(0.101)
$Max\ Benefits$ (\$1000)		0.0266
		(0.0535)
Person time-varying controls	✓	✓
Person FE	✓	✓
State-Year FE	✓	✗
State-Year Controls	✗	✓
State FE	✗	✓
Year FE	✗	✓
Worker-Year Observations	32,090	32,090
Number of Workers	13371	13,371
Number of States	46	46
R^2	0.286	0.281

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

Note: This table reports the coefficient estimates for specification 1.4 for the near-retirement population (50-59 years old) with 401(k) asset growth as the dependent variable in two specifications with and without state-year fixed effects. Person time-varying controls include lagged versions of other liquid taxable assets held by the worker and those jointly held with spouse, earnings, credit card debt, store bills and rent or mortgage payments. In column (2), state-level controls include lagged versions of wage levels, per capita income and unemployment rates. Standard errors are clustered at the state level.

Table 1.7: Interaction of UI with Self-insurance Assets (Precautionary financial assets held outside of retirement accounts)

	$\Delta\, log(401(k) Assets + 10)$
$Max\ Benefits$ (\$1000) $\times$ $On\ Layoff$	0.0918***
	(0.0211)
$Max\ Benefits$ (\$1000) $\times$ $On\ Layoff$ $\times$ $Liquid\ Assets$	-0.0922***
	(0.0292)
$On\ Layoff$	-0.167*
	(0.0944)
Person time-varying controls	✓
Person FE	✓
State-Year FE	✓
Worker-Year Observations	32,090
R^2	0.288

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

Note: This table reports the coefficient estimates for specification 1.4 for the population aged 50-59 years old with 401(k) asset growth as the dependent variable with an additional interaction term between layoff status, unemployment benefit generosity and precautionary non-retirement savings held outside of retirement accounts (including checking and savings accounts, bonds and stocks measured in \$100,000s). Person time-varying controls include lagged versions of other liquid taxable assets held by the worker (and those jointly held with spouse), earnings and rent (or mortgage payments) and controls for pairwise combinations of layoff status, UI benefits generosity and liquid non-retirement assets. Standard errors are clustered at the state level.

Table 1.8: The Mitigating Effect of Unemployment Insurance on Early Social Security Claiming Behavior

	$Pr[SS\ Income_{t+1} > 0 \mid SS\ Income_t = 0]_{ist_{Age}}$
Panel A: Individuals age 61	
$Job\ Loss$	0.263***
	(0.0785)
$Max\ Benefits(\$1000) \times\ Job\ Loss$	-0.0448*
	(0.0260)
State-Year FE	✓
Observations	1,268
R^2	0.157
Panel B: Individuals age 62	
$Job\ Loss$	0.243**
	(0.109)
$Max\ Benefits(\$1000) \times\ Job\ Loss$	-0.0906**
	(0.0354)
State-Year FE	✓
Observations	814
R^2	0.147
Panel C: Individuals age 63	
$Job\ Loss$	0.477***
	(0.162)
$Max\ Benefits(\$1000) \times\ Job\ Loss$	-0.110
	(0.0912)
State-Year FE	✓
Observations	540
R^2	0.217
Panel D: Individuals age 64 (Placebo test)	
$Job\ Loss$	0.0904
	(0.0881)
$Max\ Benefits(\$1000) \times\ Job\ Loss$	0.0116
	(0.0725)
State-Year FE	✓
Observations	434
R^2	0.232

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

Note: This table provides the coefficient estimates for specification 1.5 estimated separately for individuals of age 61, 62, 63 and 64. For workers age 61, 62 and 63, a job loss increases the propensity to initiate social security benefits immediately after at 62, 63 and 64 respectively. State unemployment benefit generosity reduces this likelihood and incentivizes older job losers to delay their social security benefits claiming. Unemployment benefits do not incentivize delays in social security benefit receipt beyond the full retirement age, 65. All regressions control for gender, marital status and lagged earnings. Standard errors are clustered at the state level.

Figure 1.1: Age Profile of IRA and Employer-Sponsored 401(k) Assets

Figure 1A

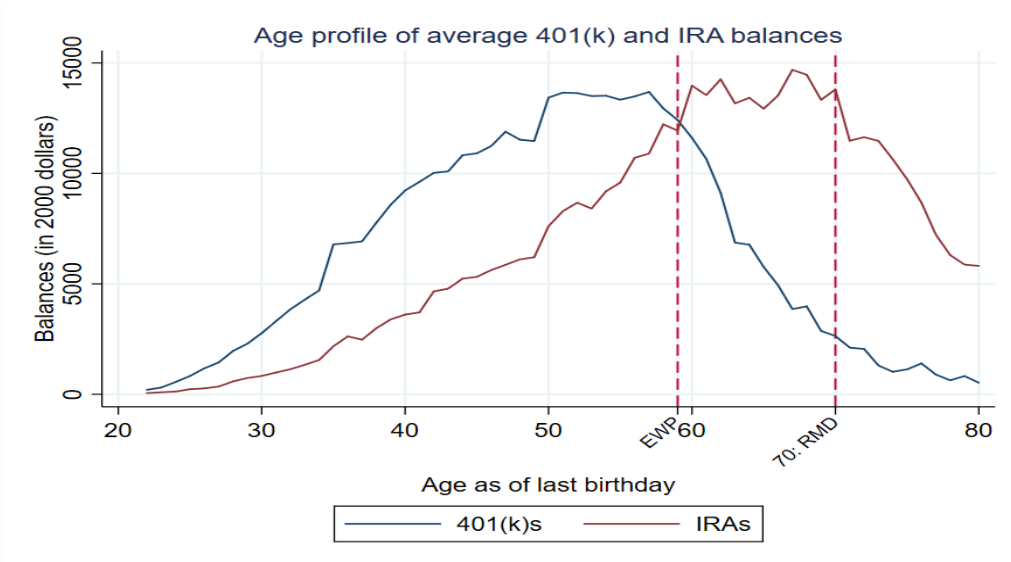
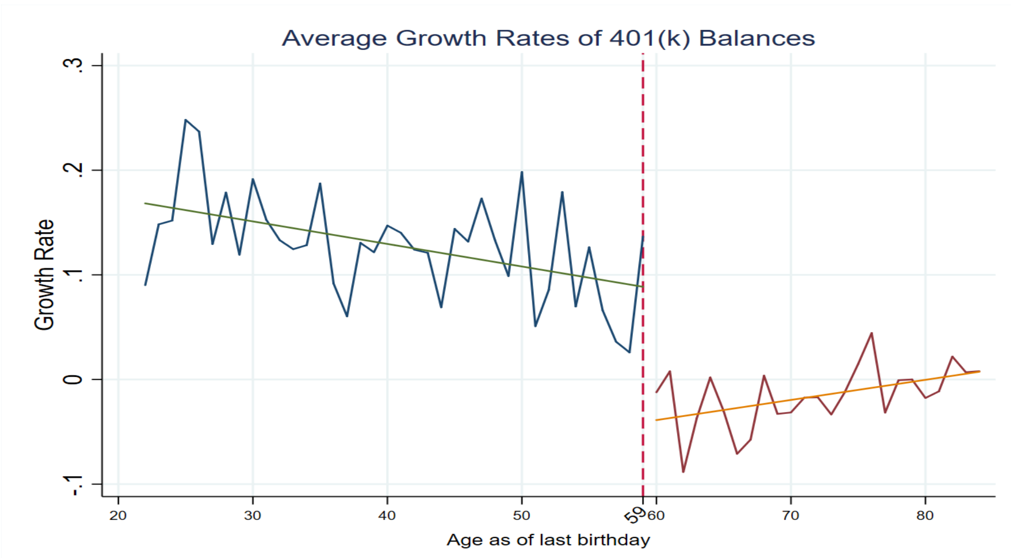
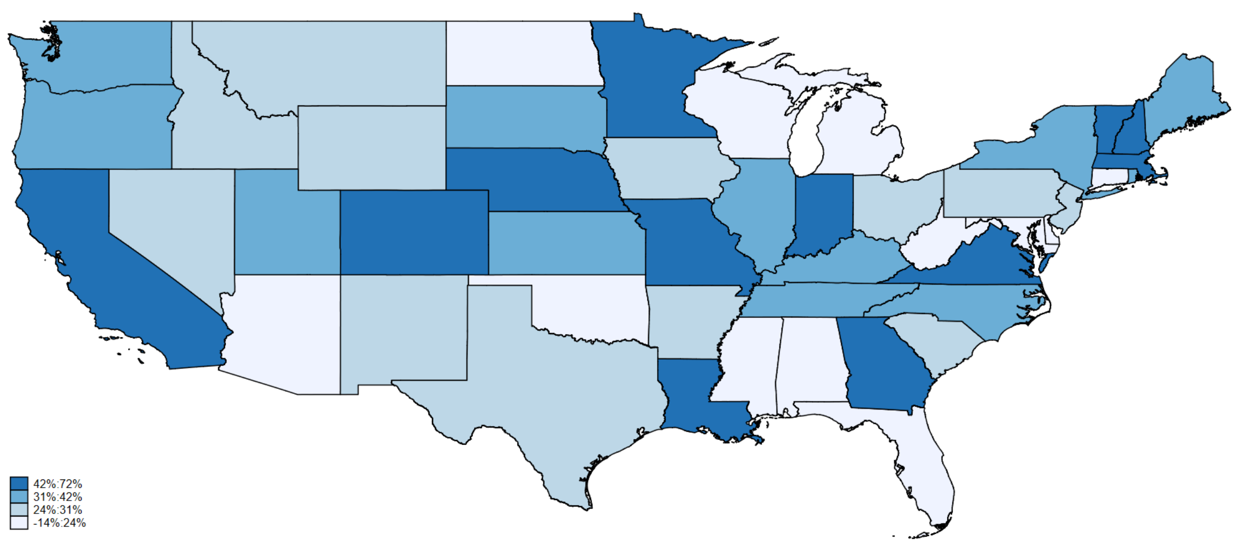


Figure 1B



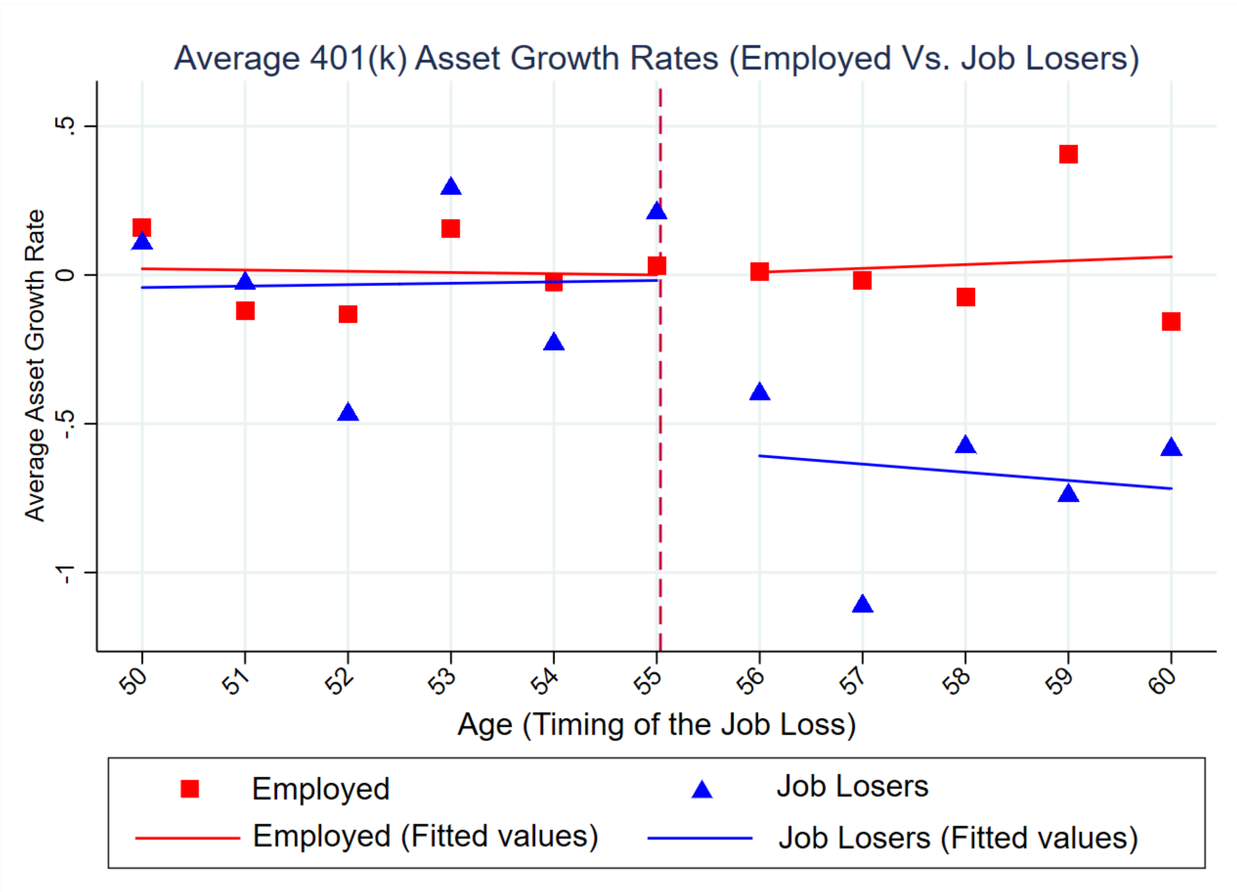
Note: The upper figure illustrates the age profile of the population average asset holdings (in 2000's \$) in IRA and 401(k) accounts. The two dashed vertical lines indicate the $59\frac{1}{2}$ and $70\frac{1}{2}$ age thresholds, corresponding to the removal of the Early Withdrawal Penalty and the Required Minimum Distribution respectively. The lower figure illustrates the age profile of the average growth rate of 401(k) asset holdings. The dashed vertical lines indicates the $59\frac{1}{2}$ age threshold, corresponding to the removal of the Early Withdrawal Penalty. Two lines are fitted before and after the removal of the penalty. A one-off step decline in 401(k) asset growth rates is observed immediately after the removal of the penalty at age $59\frac{1}{2}$. Source: SIPP 1996 and 2001 Asset topical modules.

Figure 1.2: Geographic Distribution of Regular State Unemployment Benefits Changes by quartile over the period 1996-2003



Note: The figure describes the geographic distribution of the changes in unemployment insurance over time by quartile. Darker shades of blue indicate larger increases in state unemployment benefits over the period 1996-2003. Source: Hsu, Matsa, and Melzer (2018).

Figure 1.3: Average Growth Rates of Assets held in Employer-Sponsored 401(k) pensions following a Job Loss at Different Ages around age 55 compared to employed workers



Note: The figure plots the average growth rates of employer-sponsored 401(k) pensions by age within the range 50-59 years old net of person fixed effects, for job losers and non-job losers. The treatment group (fitted blue line) is the average 401(k) asset growth rates for the population that experienced a job loss at each age. The control group (fitted red line) consists of the average growth rates for the population that didn't experience a layoff at that age. The dashed vertical line indicates age 55 at which the tax-price (EWP) of unemployment-motivated access to 401(k) accounts changes from 10% to zero. Only 401(k) account owners are considered for the purpose of this illustration. Source: SIPP Asset data linked to labor market histories collected from SIPP core modules.

Chapter 2

The Propagation of Local Credit Shocks: Evidence from Hurricane Katrina

2.1 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]

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, Sraer, and Thesmar 2017]. Local loan demand shocks

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

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, Black, and Keeton 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 (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, Loutskina, and Strahan (2016) and Chakraborty, Goldstein, and MacKinlay (2018), 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 2.1, 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 2.1 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, Black, and Keeton (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, Goldstein, and MacKinlay (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, Kapan, and Minoiu 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, Loutskina, and Strahan (2016) and Chakraborty, Goldstein, and MacKinlay (2018) 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 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. 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.

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].

2.2 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]

2.2.1 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 follows:[6]

$$W_{ij} = \frac{Lending\ by\ Institution_i\ in\ CBSA_j\ or\ County_j}{Total\ Mortgage\ Lending\ in\ CBSA_j\ or\ County_j} \tag{2.1}$$

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 B.1. In Appendix Figure B.2, I provide an overview of the extent and the distribution 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.

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

2.2.2 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:

$$PExp_i = \frac{Lending\ by\ Institution_i\ in\ Katrina\ Areas}{Total\ Mortgage\ Lending\ by\ Institution_i} \tag{2.2}$$

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]

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

$$Link_j = \sum_{i=1}^{N} W_{ij} \times PExp_i \tag{2.3}$$

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 2.2 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 2.2 about here]

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

2.2.4 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 aggre-

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.

gation of linkages via the different types of HMDA-reporting institutions.[8] Accordingly, equation (3) can be re-written as follows:[9]

$$Link_j = \sum_{k=1}^{K} \sum_{i=1}^{N_k} W_{ikj} \times PExp_{ik} \tag{2.4}$$

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, Sraer, and Thesmar (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 2.2 about here]

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 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.

2.2.5 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 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.

2.2.6 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.

2.3 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:

$$Activity_{it} = \alpha + \eta_i + \zeta_t + \sum_{\tau \neq 2004} \mathbb{1}[\tau = t] \times Disaster_i \times \mu_\tau + \epsilon_{it} \tag{2.5}$$

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 and 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].

$Activity_{it}$ 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 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 2.3 and 2.4, 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 and 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 devel-

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.

opment (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 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 2.3 and 2.4 about here]

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

2.4.1 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]

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

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, Loutskina, and Strahan (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.

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:

$$Market\ Entry_{ict} = \alpha + \eta_{ic} + \gamma_{it} + \sum_{\tau \neq 2004} \mathbb{1}[\tau = t] \times Katrina_c \times \mu_\tau + \epsilon_{ict} \tag{2.6}$$

$Market\ Entry_{ict}$ is a binary indicator that equals one if bank i originated at least one loan in 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 2.5, 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

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

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 2.3, 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 2.5 and reported in table 2.3, 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 geographic substitution by banks towards disaster areas.

[Figure 2.5 and Table 2.3 about here]

2.4.2 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 2.2, 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:

$$CS_{ict} = \alpha + \eta_{ic} + \zeta_{ct} + \sum_{\tau \neq 2004} \mathbb{1}[\tau = t] \times PExp_i \times \mu_\tau + \Gamma X_{it} + \epsilon_{ict} \qquad (2.7)$$

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.

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 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, Loutskina, and Strahan (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 2.2. $\mathbb{1}[\tau = t]$ are a set of indicator functions that equal one at their corresponding years and zero otherwise.

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.

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 2.6, 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 2.4 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 2.5. 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 2.6 and Table 2.4 about here]

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 2.5 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 2.4 to show that national OCC-regulated banks had a stronger response to this shock compared to state banks [Table 2.2]. Accordingly, I re-estimate specification 2.7 separately for the sets of national and state banks. The estimates reported in columns (2) and (3) of Table 2.4 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.

21. This observation is consistent with Landier, Sraer, and Thesmar (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.

2.4.3 The Economic Trade-off driving Resource Re-allocation

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 in Figures 2.5 and 2.6.

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

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 et 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 2.6 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 pro-

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

vided in columns (1) and (2) of Table 2.6 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 2.6 about here]

The results shown in Table 2.6 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, Goldstein, and MacKinlay (2018), unconstrained institutions are less responsive to local shocks.

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 2.3 and 2.4. 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:

$$IR_{st} = \alpha + \eta_s + \zeta_t + \beta_1 \times \mathbb{1}[Year > 2005] \times Katrina_s + \epsilon_{st} \tag{2.8}$$

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 2.3 and 2.4). I show, in table 2.7, 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 2.7 about here]

2.4.4 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, Goldstein, and MacKinlay (2018), I show that significant amounts of mortgage lending are retained on balance sheets. Specifically, about 39% of

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

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 2.8 about here]

Second, I use the information provided by HMDA data to compute banks' retained origination volumes in each local market. Using specification 2.6, 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 2.3 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 B.4]. 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.

2.4.5 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

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, Gerardi, and Hartman-Glaser (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.

test by restricting the analysis to banks with less than $BN 1 of assets.[25] Accordingly, I re-estimate specification 2.6 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 2.9 about here]

2.5 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 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 2.3. 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

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.

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]

2.5.1 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 2.1 shows the evolution of 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

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.

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 2.5 and 2.6 and the reconstruction process in the damaged regions shown in Figures 2.3 and 2.4.

2.5.2 Specification

To formally identify the exact timing of the divergence observed in figure 2.1, I estimate the following event study specification:

$$ln(HPI_{ist}) - ln(HPI_{ist-1}) = \alpha + \eta_{is} + \zeta_{st} + \sum_{\tau \neq 2004:Q4} \mathbb{1}[\tau = t] \times Link_{is} \times \mu_\tau + X_{ist}\Gamma + \epsilon_{ist} \tag{2.9}$$

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, Mayer, and Sinai 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 and 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 2.3. 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]

2.5.3 Results

I present the first set of results in Table 2.10. 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 2.1. 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 2.1, with several post-Katrina coefficients being insignificant.

[Table 2.10 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 linkages to Katrina areas. Hence, for the

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

CBSA with the average financial connectedness to Katrina-affected areas (0.025 as shown in Table 2.11) , 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.

2.6 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 and 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 2.11], consistent with larger markets being more financially integrated in the financial system. I address this challenge using the following series of tests:

2.6.1 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 2.1 and supports the hypothesis of a credit-induced decline in home values in the undamaged regions.[30]

2.6.2 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 2.12 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 2.12 about here]

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.

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

$$ln(HPI_{ict}) - ln(HPI_{ict-1}) = \beta_0 + \beta_1 \times \mathbb{1}[Year > 2005] \times Link_{ic} + X_{ict}\alpha + \eta_{ic} + \zeta_{ct} + \epsilon_{ict} \tag{2.10}$$

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 2.3 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 2.13, 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 2.2), witnessed a decline of 0.96 percent in housing prices in the post-storm period.

[Table 2.13 about here]

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

2.6.3 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:

$$\Delta HPI_{ict} = \alpha + \zeta_{ct} + \sum_{\tau \neq 2004} I[\tau = t] \times Link_{ic} \times \mu_{\tau} + \epsilon_{ict} \tag{2.11}$$

$I[\tau = t]$ 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 2.7, 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 2.7 about here]

2.6.4 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

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

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 2.2. I estimate specification 2.10 with an additional interaction term including the pre-Katrina share of small scale banks in county i as follows:

$$\begin{aligned} ln(HPI_{ict}) - ln(HPI_{ict-1}) = \alpha + \eta_{ic} + \zeta_{ct} + \beta_1 \times \mathbb{1}[Year > 2005] \times Link_{ics} \\ +\beta_2 \times \mathbb{1}[Year > 2005] \times Link_{ics} \times Share\,Small_{ic} + X_{icst}\Gamma + \epsilon_{ict} \end{aligned} \tag{2.12}$$

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 2.13, 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.

2.6.5 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 and Sufi (2018), credit contractions negatively influence household demand on housing. The magnitude of the effect on local housing prices de-

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 2.2]

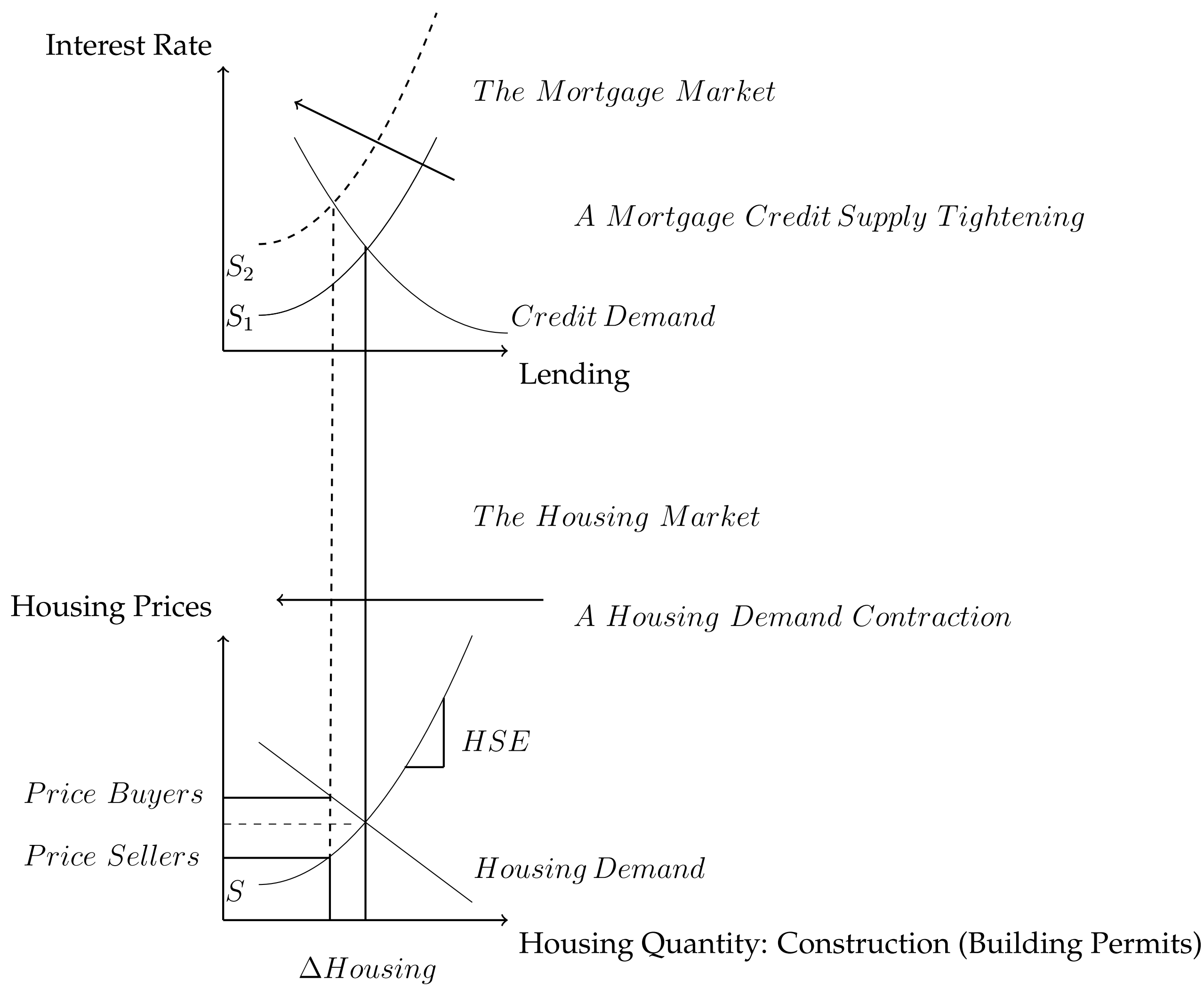
35. The average market share of banks that report the FDIC as their main regulator is about 12-13%.

pends 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 2.1. 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 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, Sraer, and Thesmar (2012), Mian and Sufi (2014) and Chetty, Sándor, and Szeidl (2017). I use a granular county-level measure computed by Lutz and 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

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

Joint Equilibrium in Local Mortgage and Housing Markets



A Credit-Induced Housing Demand Contraction: 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.

difference specification to leverage this third layer of variation:

$$\begin{aligned} Y_{ict} = \alpha + \beta_1 \times \mathbb{1}[Year > 2005] \times HSE_{ic} + \beta_2 \times \mathbb{1}[Year > 2005] \times Link_{ic} \\ + \beta_3 \times \mathbb{1}[Year > 2005] \times Link_{ic} \times HSE_{ic} + X_{ict}\Gamma + \eta_{ic} + \zeta_{ct} + \epsilon_{ict} \end{aligned} \tag{2.13}$$

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 and 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-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).

$$\begin{aligned} \beta_2 = (E[Y_{it}|Inelastic, Linked, Post] - E[Y_{it}|Inelastic, Linked, Pre]) \\ -(E[Y_{it}|Inelastic, Unlinked, Post] - E[Y_{it}|Inelastic, Unlinked, Pre]) \end{aligned} \tag{2.14}$$

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

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.

$$\begin{aligned}\beta_3 = &\overbrace{(E[Y_{it}|Elastic, Linked, Post] - E[Y_{it}|Elastic, Linked, Pre])}^{\beta_3+\beta_2+\beta_1} \\ &- \overbrace{(E[Y_{it}|Inelastic, Linked, Post] - E[Y_{it}|Inelastic, Linked, Pre])}^{\beta_2} \\ &- \overbrace{(E[Y_{it}|Elastic, Unlinked, Post] - E[Y_{it}|Elastic, Unlinked, Pre])}^{\beta_1} \\ &- \overbrace{(E[Y_{it}|Inelastic, Unlinked, Post] - E[Y_{it}|Inelastic, Unlinked, Pre])}^{0}\end{aligned} \tag{2.15}$$

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 2.13, I compute the average treatment effect as follows:

$$ATE = (\hat{\beta}_2 + \hat{\beta}_3 \times \overline{HSE_{ic}}) \times \overline{Link_{ic}} = (-0.408 + 0.372 \times 0.1336) \times .0248 \approx -0.89\% \tag{2.16}$$

Accordingly, I report a decline in housing prices of %0.89 relative to pre-storm prices for the county 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 2.10.

2.6.6 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:

$$\begin{aligned}\Delta Q_{ict} = \alpha + \beta_1 \times \mathbb{1}[Year > 2005] \times HSE_{ic} + \beta_2 \times \mathbb{1}[Year > 2005] \times Link_{ic} \\ +\beta_3 \times \mathbb{1}[Year > 2005] \times Link_{ic} \times HSE_{ic} + X_{ict}\Gamma + \zeta_{ct} + \epsilon_{ict}\end{aligned} \tag{2.17}$$

Q is the number of annually issued building permits corresponding to housing units or residential buildings or the monetary valuation of the structures aggregated at the county-year level.[39] 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 2.14 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.

[Table 2.14 about here]

2.7 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

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

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, Loutskina, and Strahan (2016), Cetorelli and Goldberg (2012), Peek and Rosengren (1997) and Hale, Kapan, and Minoiu (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, Loutskina, and Strahan (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.

2.8 Tables and Figures

Table 2.1: 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 2.2: 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 2.3, 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 2.3: Post-Katrina Banks' Capital Flow Towards Disaster Areas

	(1) Market Entry Decision	(2) Total Lending	(3) Retained Lending
1[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 2.6. 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 2.5. 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 2.4: 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* (0.156)	-0.346** (0.165)	-0.0239 (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 2.7. 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 2.2 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 2.5: 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 2.6: 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[Year>2005] $\times \mathbb{1}[Disaster\ Area]$	0.0606***	-0.0158	0.0515***	0.0267**
	(0.0135)	(0.0196)	(0.0177)	(0.0129)
$H_0 : (\beta_{Constrained} = \beta_{Unconstrained})$	Reject ($z_{score} = 3.21$)		Fail to Reject ($z_{score} = 1.13$)	
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 2.6 for the set of financially unconstrained banks (High deposit funding & 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 2.7: 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 2.8: 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 2.9: Insignificant Response for Community Banks

	Market Entry Decision
1[Year>2005] $\times \mathbb{1}[\textit{Disaster Area}]$	-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 2.6 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 2.10: 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 2.9. 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 2.1. 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 2.11: 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 2.3. 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 2.12: 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 & Sand (2017).

Table 2.13: 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 2.10, 2.12 and 2.13. 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.

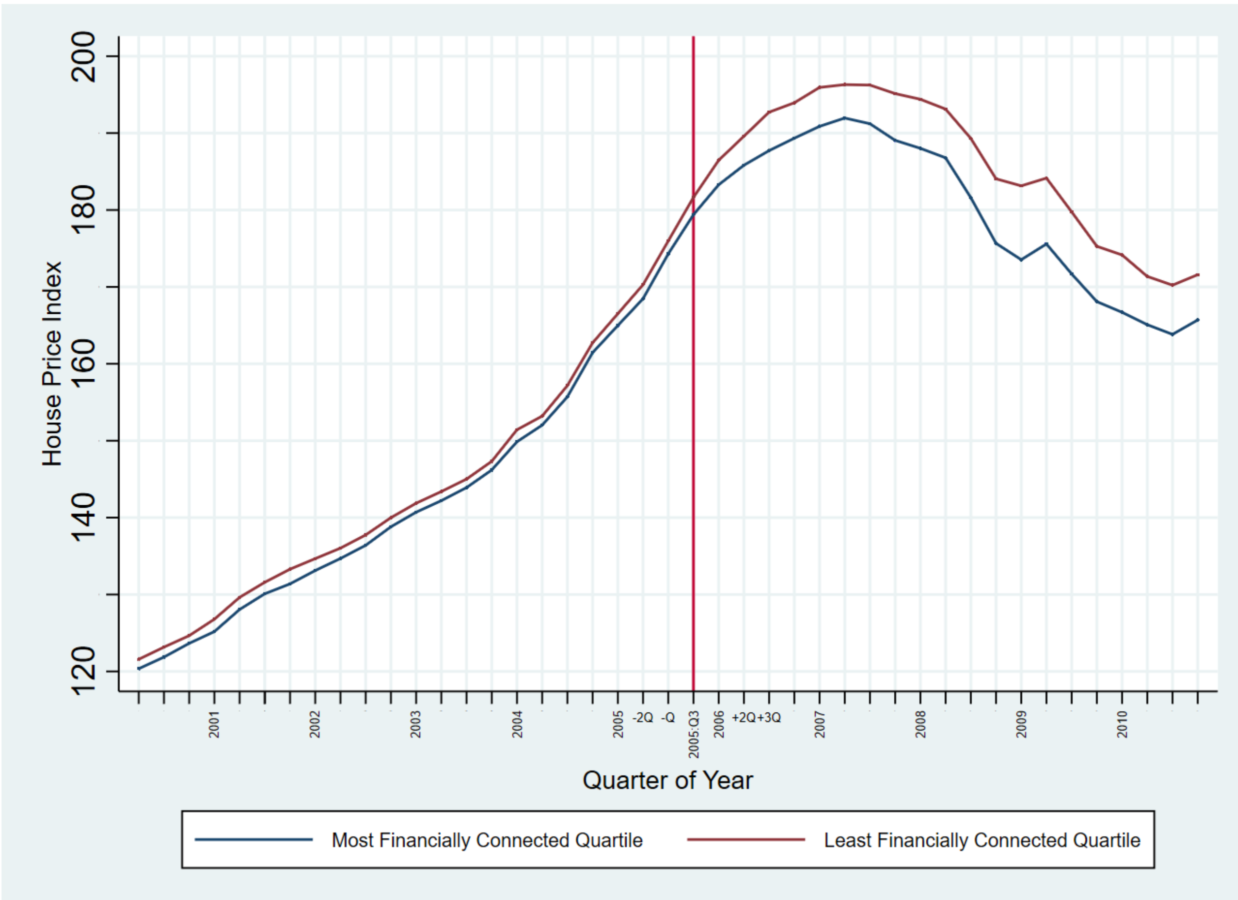
Table 2.14: Triple Difference Analysis using Housing Supply Elasticity: Housing Quantities Response (Units, Buildings and Monetary Valuation of Construction Work)

	(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

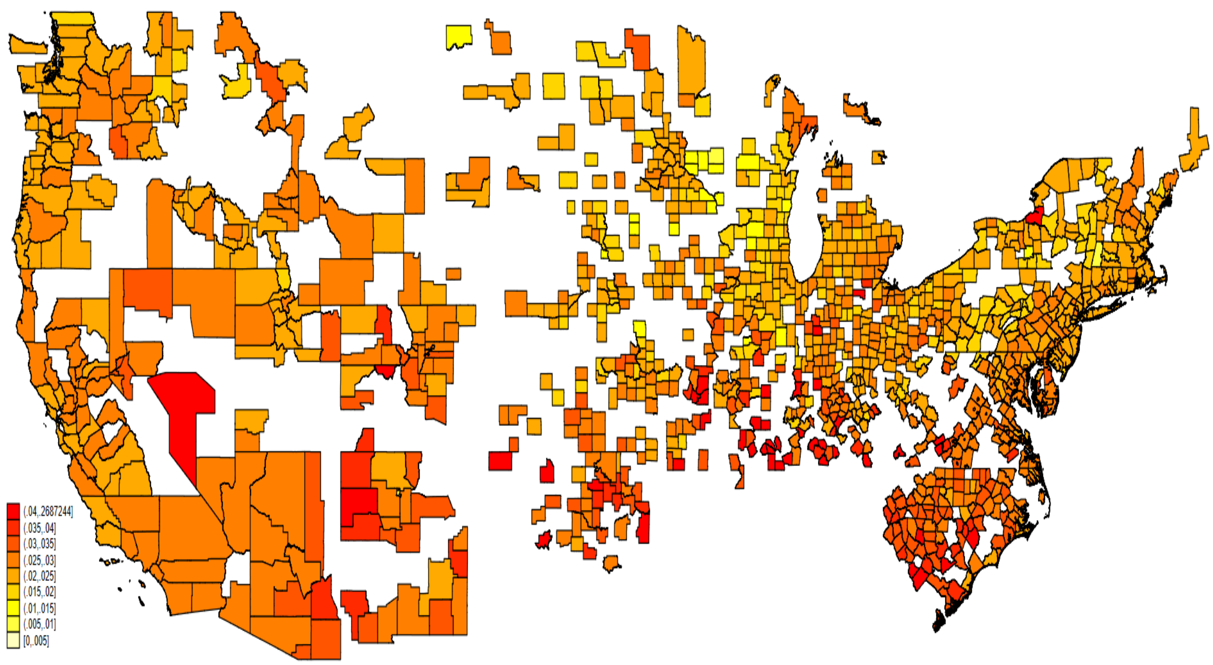
Note: This table reports coefficients' estimates from difference-in-difference-in-difference specification 2.17. $Link$ is the measure of financial linkages to Katrina areas. HSE refers to the housing supply elasticity measure computed as the inverse of the land unavailability measure of Lutz & Sand (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 2.1: 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).

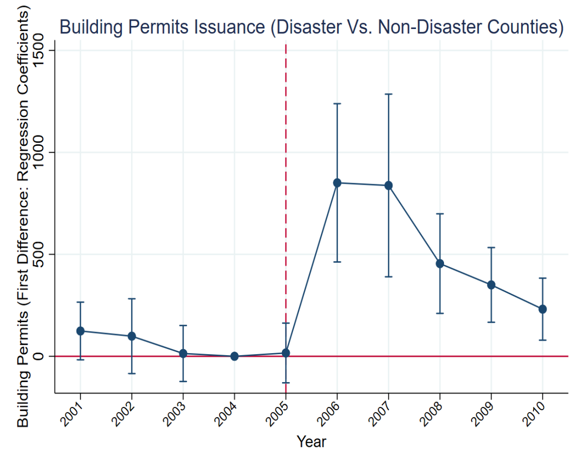
Figure 2.2: Financial Inter-linkages to Katrina-hit Regions



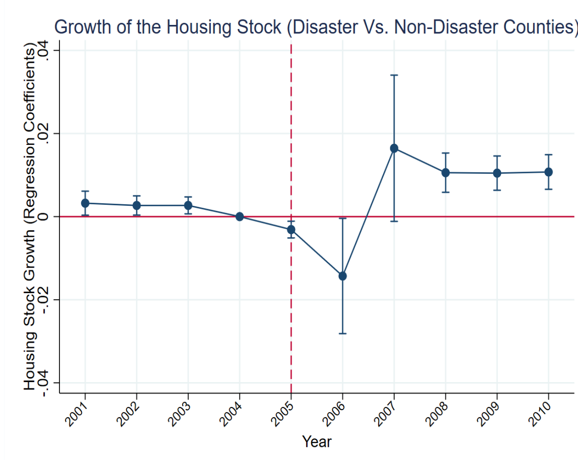
Note: The figure shows a heat map of financial linkages of all urban counties (located within a Core-Based Statistical Area) in the mainland United States, outside of disaster areas and their adjacent states. Alabama, Arkansas, Florida, Georgia, Louisiana, Mississippi, Tennessee and Texas are dropped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

Figure 2.3: 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

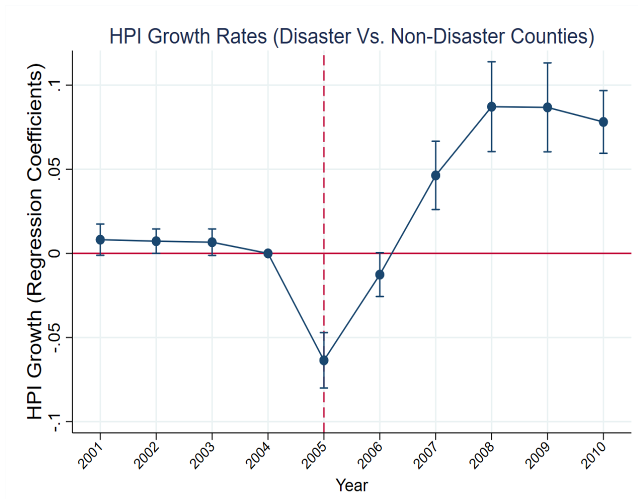
Post-Katrina Surge in Building Permits Issuance



Post-Katrina Surge in Housing Stock Growth



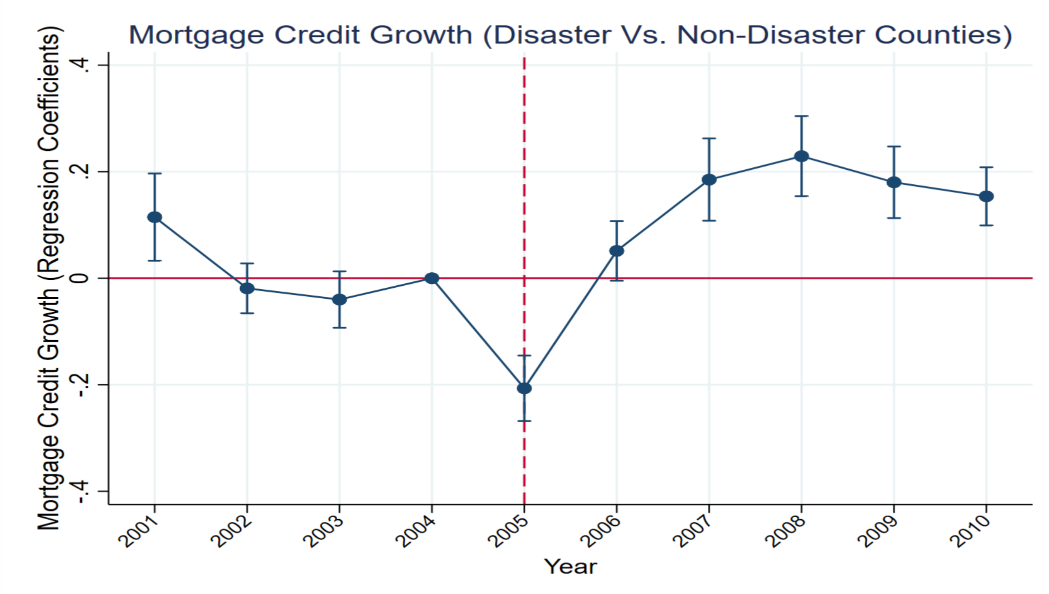
Faster Home Value Appreciation after the storm



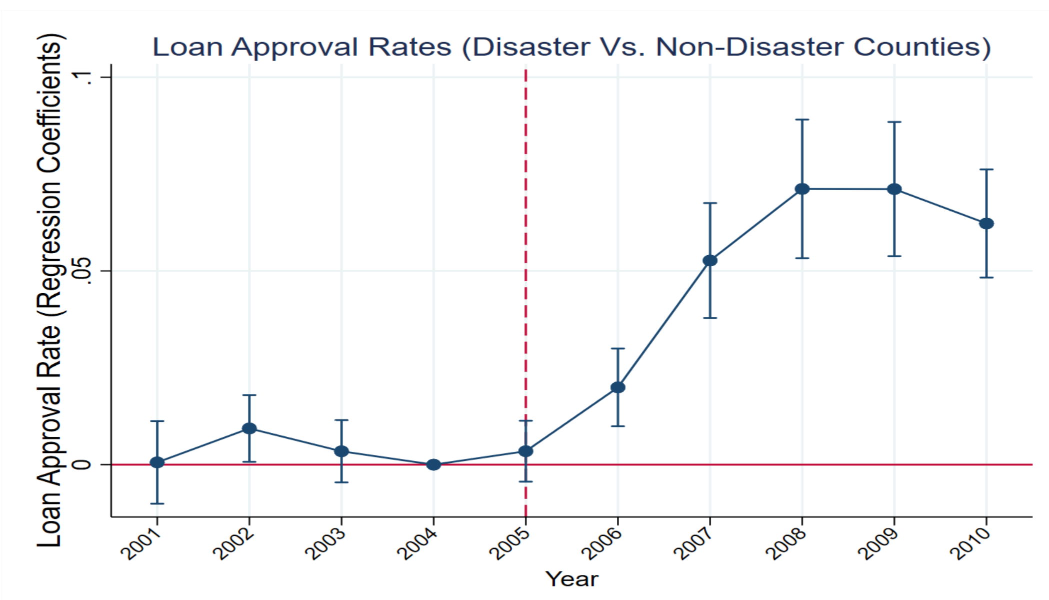
Note: This figure plots the coefficients' estimates of specification 2.5. The dashed vertical line indicates the year of the hurricane. The three sub-figures document abnormal housing market and construction activities in Katrina-damaged counties compared to the neighboring undamaged counties. This includes 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 2.4: 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 the Growth of Mortgage Credit Volumes in disaster areas



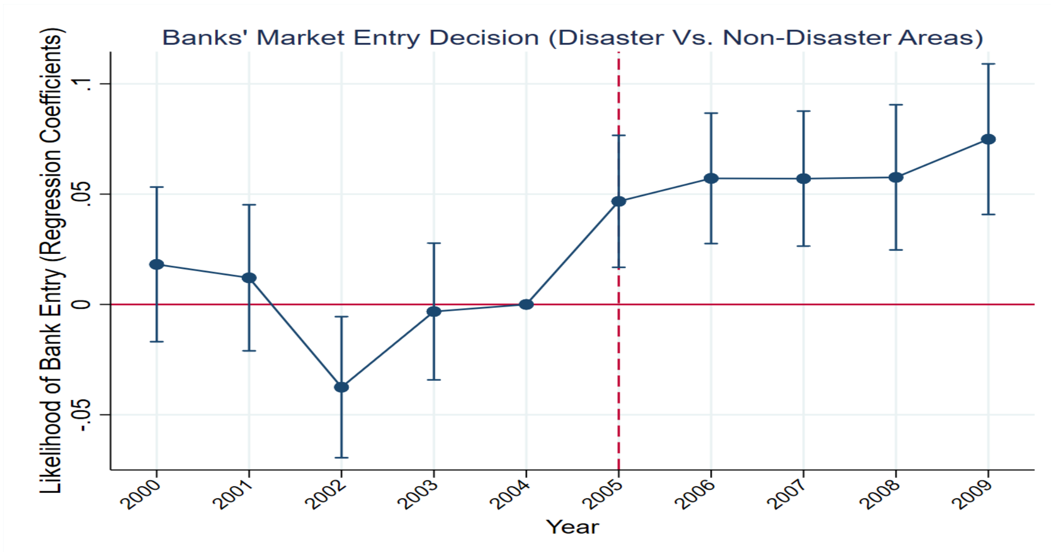
Post-Katrina Surge in Loan Approval Rates in disaster areas



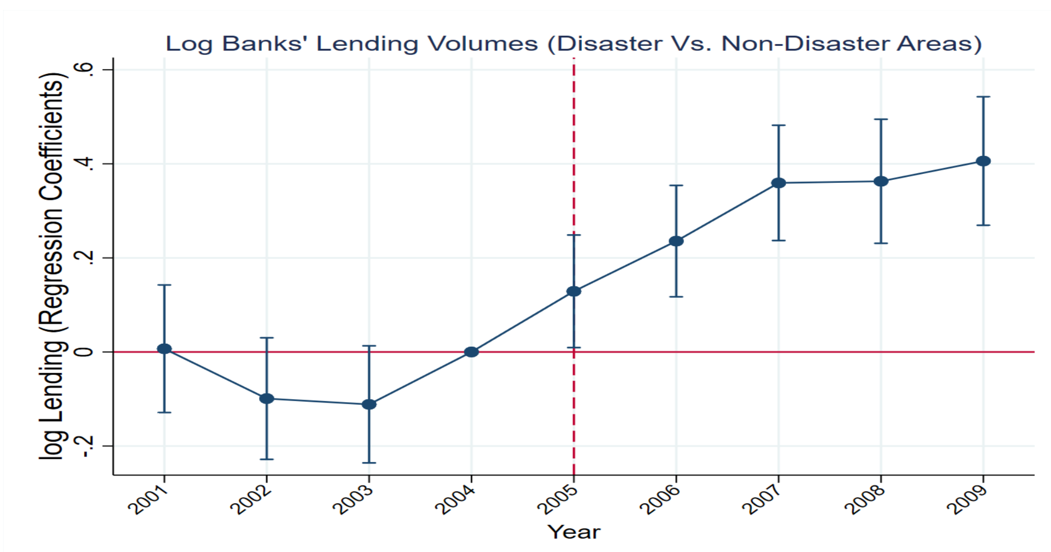
Note: This figure plots the coefficients' estimates of specification 2.5. The dashed vertical line indicates the year of Katrina. The two sub-figures document the abnormal activity in the mortgage market in the aftermath of the storm including, a sharp increase in the average loan approval rates (left 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 2.5: Post-Katrina Surge in Banks' Entry and Lending in disaster markets

Post-Katrina Surge in Banks' Market Entry in disaster areas

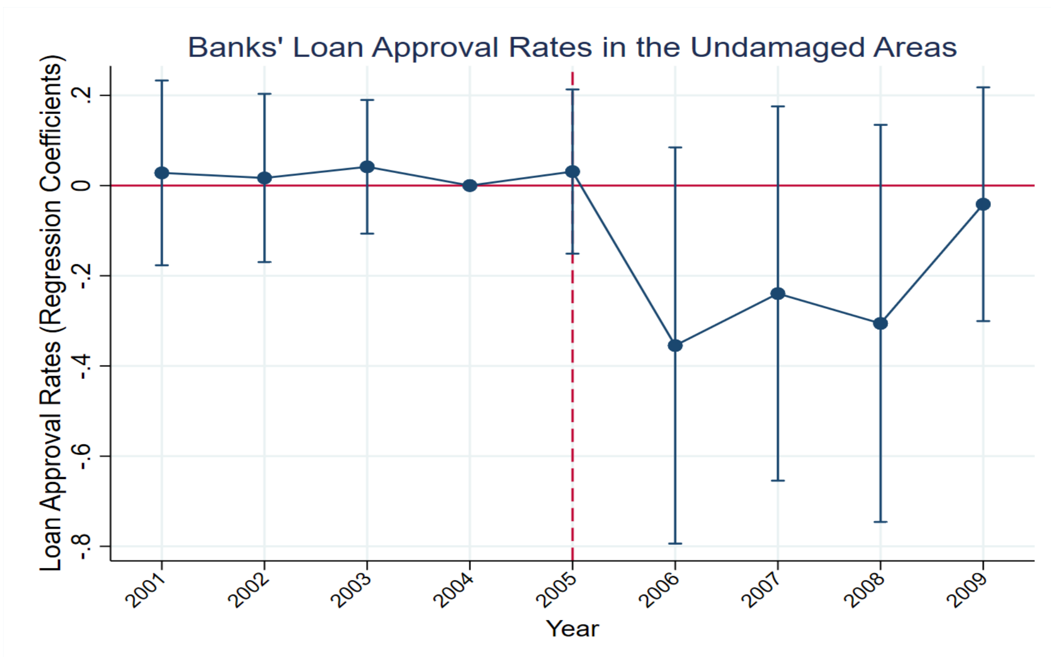


Post-Katrina Surge in Banks' Lending in disaster areas



Note: The upper figure plots the coefficients' estimates of specification 2.6. 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.

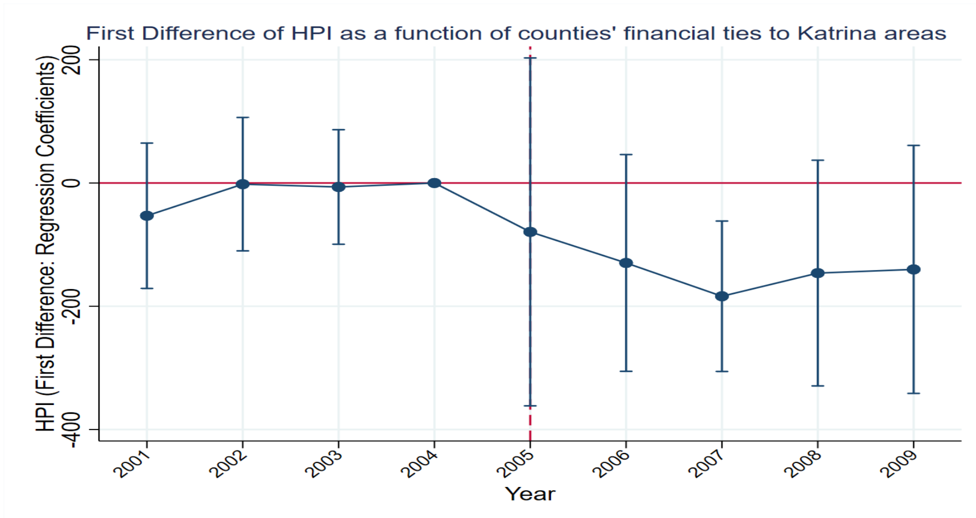
Figure 2.6: Abrupt decline in Loan Approval Rates in the Undamaged Regions as a function of Bank's historic market Presence (Geographic Footprint) in Katrina-affected regions



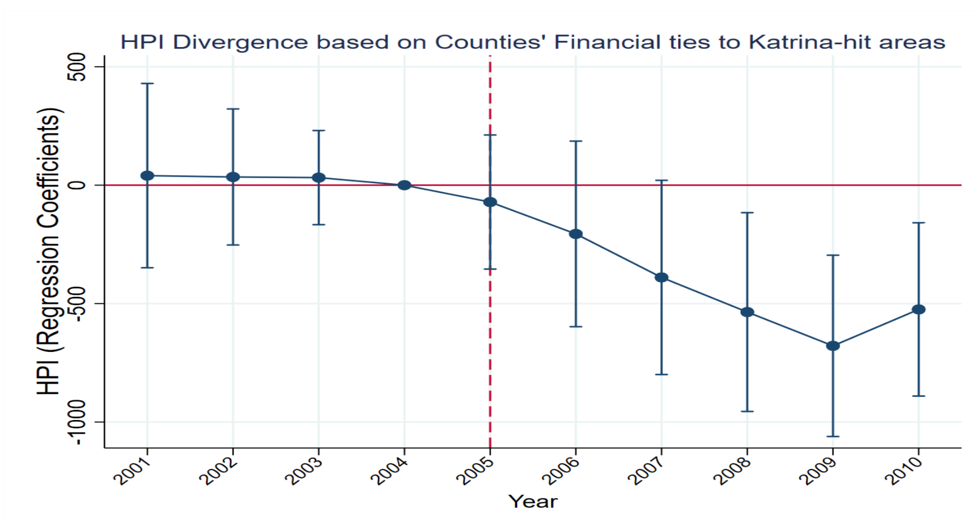
Note: This figure plots the coefficients' estimates using equation 2.7. The dashed vertical line indicates the year of the hurricane. The figure shows that banks with historic market presence in Katrina areas significantly reduced their loan approval rates in the distant undamaged areas (outside of Katrina-affected 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 2.4 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 2.7: 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 2.11. 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.

Appendices

Appendix A

Supplemental Material to Chapter 1

I Data and Variables Definitions:

I.1 Data Structure

The data used are from the 1996 and 2001 panels of the Survey of Income and Program Participation (SIPP). SIPP includes core waves and topical modules. Core waves are used to collect information on workers' labor market histories, earnings and Social Security (SS) income receipt. The 1996 panel provides 12 core waves of data spanning the period 1996-1999 while the 2001 panel provides 9 waves spanning the period 2001-2003. Topical modules are the source of information on workers' asset holdings including assets held in retirement accounts, 401(k)s and IRAs. Asset data are collected on a yearly basis along with waves 3,6,9 and 12 (where available). Accordingly, the 1996 SIPP panel tracks asset data for four consecutive years while the 2001 panel tracks asset data for three years. Using both core and topical modules, I link workers' labor market histories to their pension outcomes based on the following timing of data collection. Each set of consecutive three cores of SIPP (waves 1-3, 4-6, 7-9 and 10-12) cover approximately a calendar year. Asset data are collected approximately at the end of the calendar year or at the beginning of the following year depending on the rotation schedule determining the date of the interview.

I.2 Tax-Deferred Asset Data

Similar to Gelber (2011), I use the 401(k) asset data labeled *taltb* and provided in the annual topical modules in response to the following survey question: *As of the last day of the reference period, what was the total balance or market value (including interest earned) of any 401K or thrift plans held in ...'s own name?* The IRA asset information is retrieved from workers' responses to the survey question: *As of the last day of the reference period, what was the total balance or market value (including interest earned) of the IRA accounts in ...'s OWN name?*

I.3 Labor Market History Data

These end-of-year pension asset outcomes are then linked to workers' labor market histories during the year. Similar to Chetty (2008), I use weekly employment status provided by the survey variable *RWKESR* to construct a worker-year-level layoff indicator that is equal to one if a worker experienced some weeks of unemployment during the year (where a calendar year spans three consecutive waves: waves 1-3, 4-6, 7-9 and 10-12 respectively). Weekly employment status can take any of the following values: (1) With job/business - working, (2) With job/business - not on layoff, absent w/out pay, (3) With job/business - on layoff, absent w/out pay, (4) No job/business - looking for work or on layoff and (5) No job/business - not looking and not on layoff. I code *weekly Layoff status* to be equal to one for responses of (3) or (4) and zero otherwise. I then compute the number of layoff weeks during a given year and set the variable *Layoff* to be equal to one if the worker had some weeks of layoff during a given year and zero otherwise. I also identify the timing of a to be a change in the *Layoff* variable from 0 to one (conditional on the person not being out of the labor force). Accordingly, the *job separation due to a layoff* variable identifies the exact point of time (Age-Year) at which the layoff event took place. I use this variable to identify eligibility for 401(k) penalty-free withdrawals. On the other hand, the *Layoff* variable is used to identify workers' eligibility for unemployment insurance.

I.4 The *"Not in the labor force"* population

I use the same weekly employment status variable *RWKESR* to determine whether an individual is on the labor force. For that purpose, I count the number of weeks during which an individual reported his / her employment status to be *No job/bus - not looking and not on layoff*. Accordingly, I consider an individual to be retired if he / she report being unemployed and not looking for a job during all weeks of the years.

I.5 Social Security Income Receipt Data

Social Security income receipt is provided by the two variables *T01AMTA* and *ER01A* that provide information on monthly Social Security income receipt. To identify the exact Age-Month point at which individuals started collecting their benefits, I identify the transition timing from no Social Security income to some Social Security income receipt. I then truncate this exact age to the smallest age integer to graph Appendix Figure AI. Similarly, for the empirical analysis conducted in section 7 of the paper, I use the transition from no social security income at year t to some social security income reported in the following year t+1 as an indicator of social security benefits initiation. I remove few observations corresponding to workers who report disability as a reason for claiming.

II Optimal Social Security Claiming Strategy:

Initiating social security benefits entails a trade-off between the benefit amount and the duration of benefit receipt. Claiming at the Full Retirement Age (FRA), 65 for the cohorts studied in this paper, guarantees a monthly social security income equal to the worker' Primary Insurance Amount (PIA), computed based on the worker's earning history. Early claiming, relative to the FRA, enables individuals to receive benefits for a longer duration. However, early claiming is penalized by an actuarial adjustment of $\frac{5}{9}\%$ per month (or 6.67% per year of delay) for each month of difference between the FRA and the age of social security benefits initiation. On the other hand, delaying claiming beyond the FRA is rewarded by a Delayed Retirement Credit of $\frac{11}{24}\%$ per month of delay (or 5.5% per year of delay for cohorts born 1933-1935). There is no gain from delaying beyond age 70.

Accordingly, gains from delaying benefits claiming depends on survival expectations, patience (discount rate) and the worker's PIA. A healthier individual has an incentive to delay claiming since his / her stream of social security benefits is expected to last longer. A low discount rate creates an incentive for workers to delay claiming since future benefits become more valued. Similar to Coile et al. 2002, I study the case of a 62 years old worker considering the option of claiming at 62, 63, 64, 65, etc ...[1] The Expected Present Discounted Value (EPDV) of his/her stream of social security benefits can be computed as follows:

$$EPDV(Claiming\ Age) = \sum_{A=62}^{MaxAge-62} \beta^{(A-62)} \times SS(A \mid Claiming\ Age) \times P(A \mid 62)$$

$Max\ Age$ is the maximum potential longevity, 119 years in this case. β is the discount rate. $SS(A \mid Claiming\ Age)$ is the total annual amount of social security benefits the worker is entitled to at age A conditional on claiming at $Claiming\ Age$. The stream of annual total Social Security entitlements, starting age 62 onwards, can be expressed as a vector conditional on the claiming age as follows:

$$SS(A \mid Claiming\ Age) = 12 \times \begin{pmatrix} 0.8\,PIA & 0.8\,PIA & 0.8\,PIA & 0.8\,PIA & 0.8\,PIA & 0.8\,PIA & ... \\ 0 & 0.867\,PIA & 0.867\,PIA & 0.867\,PIA & 0.867\,PIA & 0.867\,PIA & ... \\ 0 & 0 & 0.934\,PIA & 0.934\,PIA & 0.934\,PIA & 0.934\,PIA & ... \\ 0 & 0 & 0 & PIA & PIA & PIA & ... \\ 0 & 0 & 0 & 0 & 1.055PIA & 1.055PIA & ... \\ 0 & 0 & 0 & 0 & 0 & 1.1PIA & ... \\ ... & ... & ... & ... & ... & ... & ... \end{pmatrix} \times \begin{pmatrix} I[Claiming\ Age = 62] \\ I[Claiming\ Age = 63] \\ I[Claiming\ Age = 64 \\ I[Claiming\ Age = 65 \\ I[Claiming\ Age = 66] \\ I[Claiming\ Age = 67 \\ I[Claiming\ Age = 68] \\ ... \end{pmatrix}$$

where $I[Claiming\ Age = n]$ is an indicator function that equals one at the worker's chosen claiming age (62 or 63 or 64 etc ...) and zero otherwise. $P(A \mid 62)$ is the probability of survival till age A (By definition, the worker is assumed to be alive at age 62) and is given by:

$$P(A \mid 62) = \prod_{i=62}^{A} P(i+1 \mid i)$$

1. For simplicity, I consider claiming strategies that involve claiming on birthdays.

Where $P(i+1 \mid i)$ is the gender and cohort-specific conditional probability of survival till age i+1 conditional on being alive at age i obtained from the social security life tables for the 1930's cohort. Accordingly, the EPDV can be expressed as multiples of PIA for a given discount rate and assuming average survival expectations. Similar to Coile et al. (2002) and Shoven and Slavov (2014), I use an interest rate of 3% to compute the EPDV (in multiples of PIA) of a single worker conditional on claiming at different birthdays starting 62.

Expected Present Discounted Value of the Social Security Benefit Stream conditional on claiming at different ages (multiples of PIAs)

	Male	Female
Claiming at Age	r=3%	r=3%
62	131.66	151.21
63	132.28	153.47
64	131.81	154.55
65	130.23	154.39

Accordingly, for a single worker claiming on his /her earnings record, optimal claiming strategies are 63 and 64 for men and women respectively. The EPDV gains from an optimal delay are 0.62 and 3.34 PIAs (relative to claiming at the earliest age of eligibility 62) for men and women respectively.

III Appendix Tables and Figures

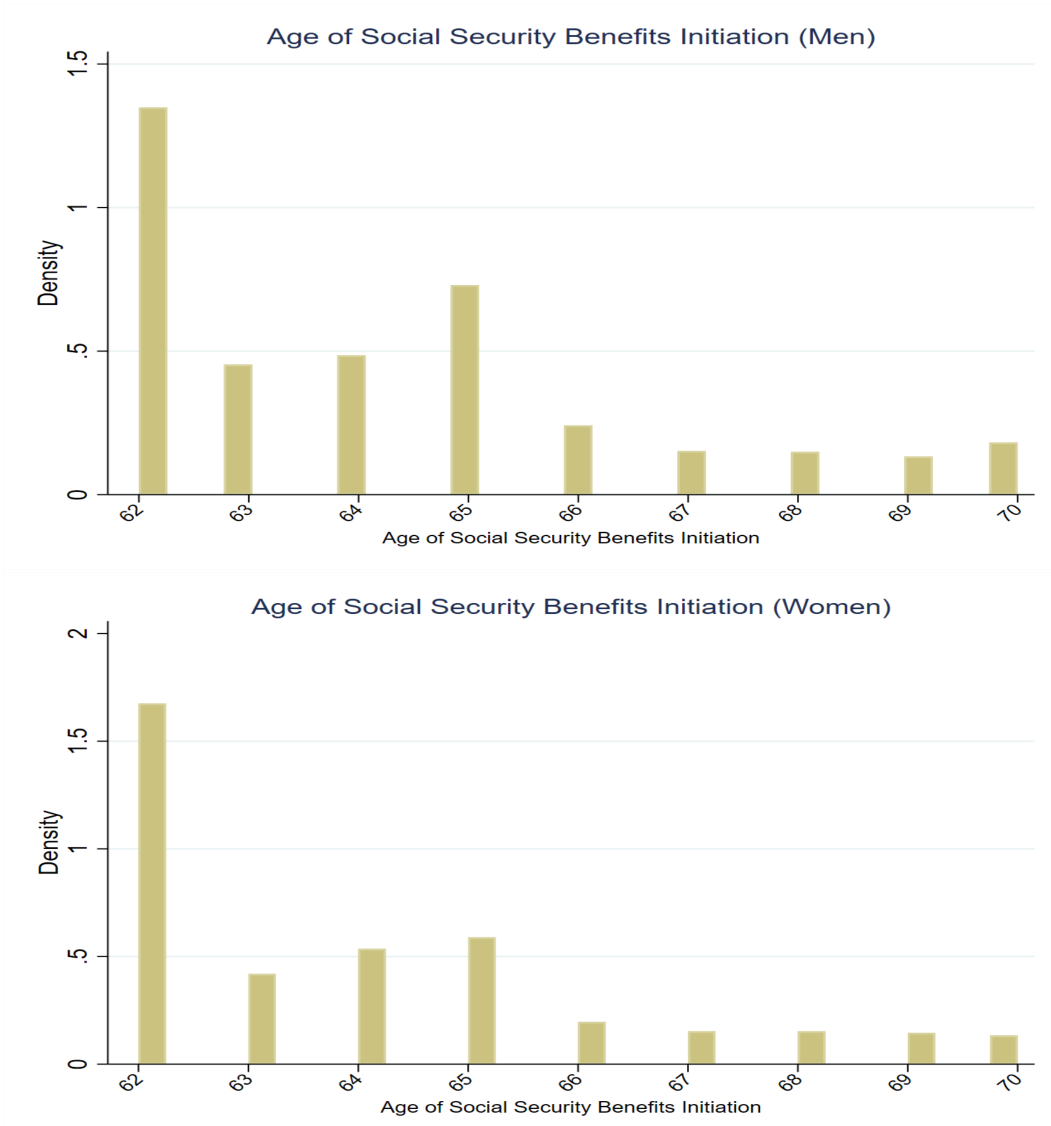
Table A.1: Retirement Accounts and financial asset holdings of the working age population (22-65) years old

	Retirement Accounts (Own Name)					
Asset Type ($)	Mean	Median	Std. dev.	Obs.	No. Workers	Account Ownership Rate
IRAs	4,975.8	0	22,941.5	287,623	104,031	19.3%
401(k)	7,975.7	0	28,831.6	287,623	104,031	28.2%

	in Own Name			Jointly with spouse		
Asset Type ($)	Mean	Median	Std. dev.	Mean	Median	Std. dev.
Checking Accounts	137.5	0	598.6	121.5	0	448.8
Interest Earning Accounts	1978.4	0	9,956.3	2,497.5	0	9,531
Bonds	578.9	0	15,577.3	456.2	0	7762.2
Stocks and Funds	6,428.4	0	314,450	8,419.7	0	462,085.2
Credit Card and Store Bills	890.2	0	19,295	913.7	0	14,982.6

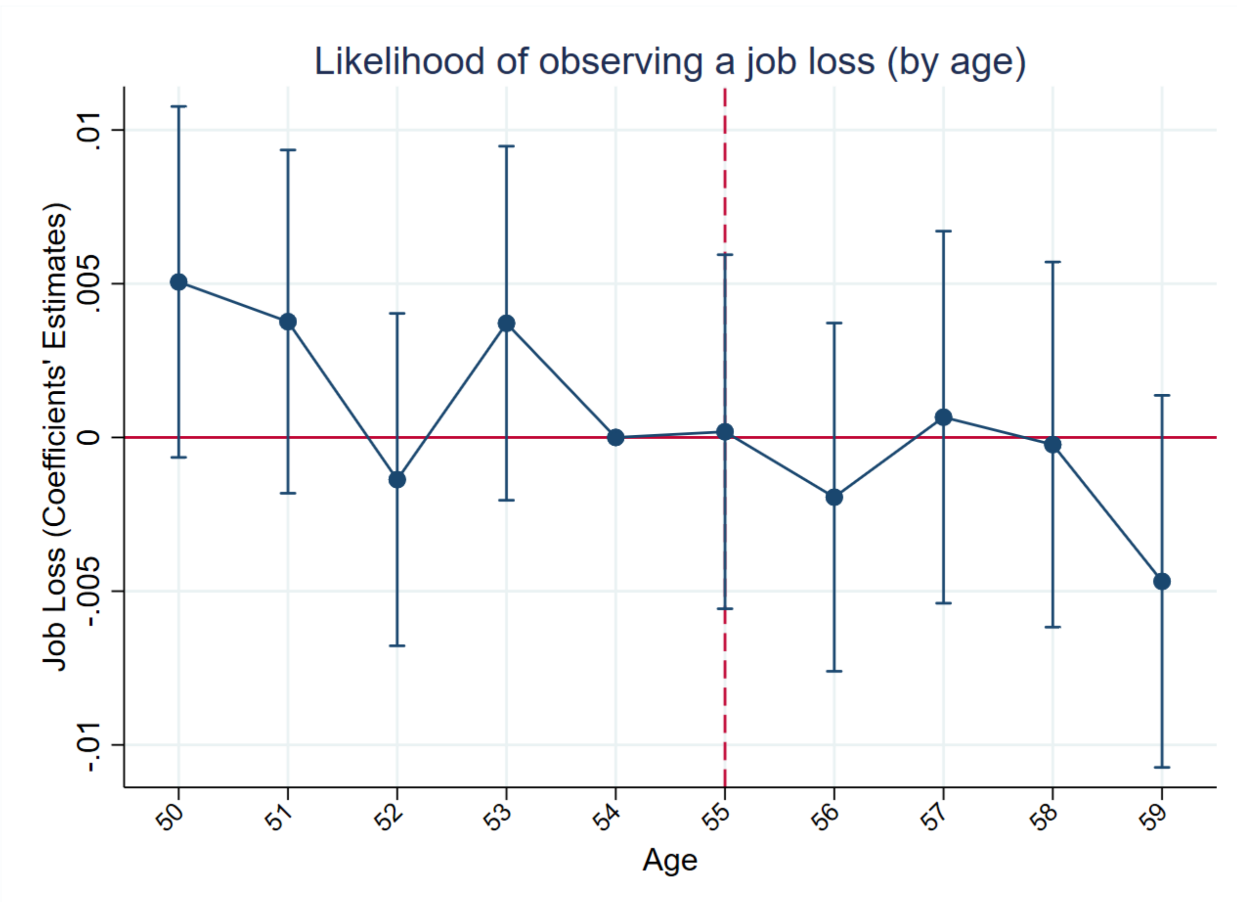
Note: This table provides summary statistics of assets held in tax-deferred retirement accounts (reported in own name), other liquid taxable savings and credit cards and store bills debt (reported in own name and jointly with spouse) for the working-age, 22-65 years old, population. The sample contains 287,623 worker-year observations. Asset values are reported in 2000's dollars. Values are obtained from the SIPP asset topical modules accompanying waves 3,6,9 and 12 (where available).

Figure A.1: Social Security Claiming Patterns (Men and Women)



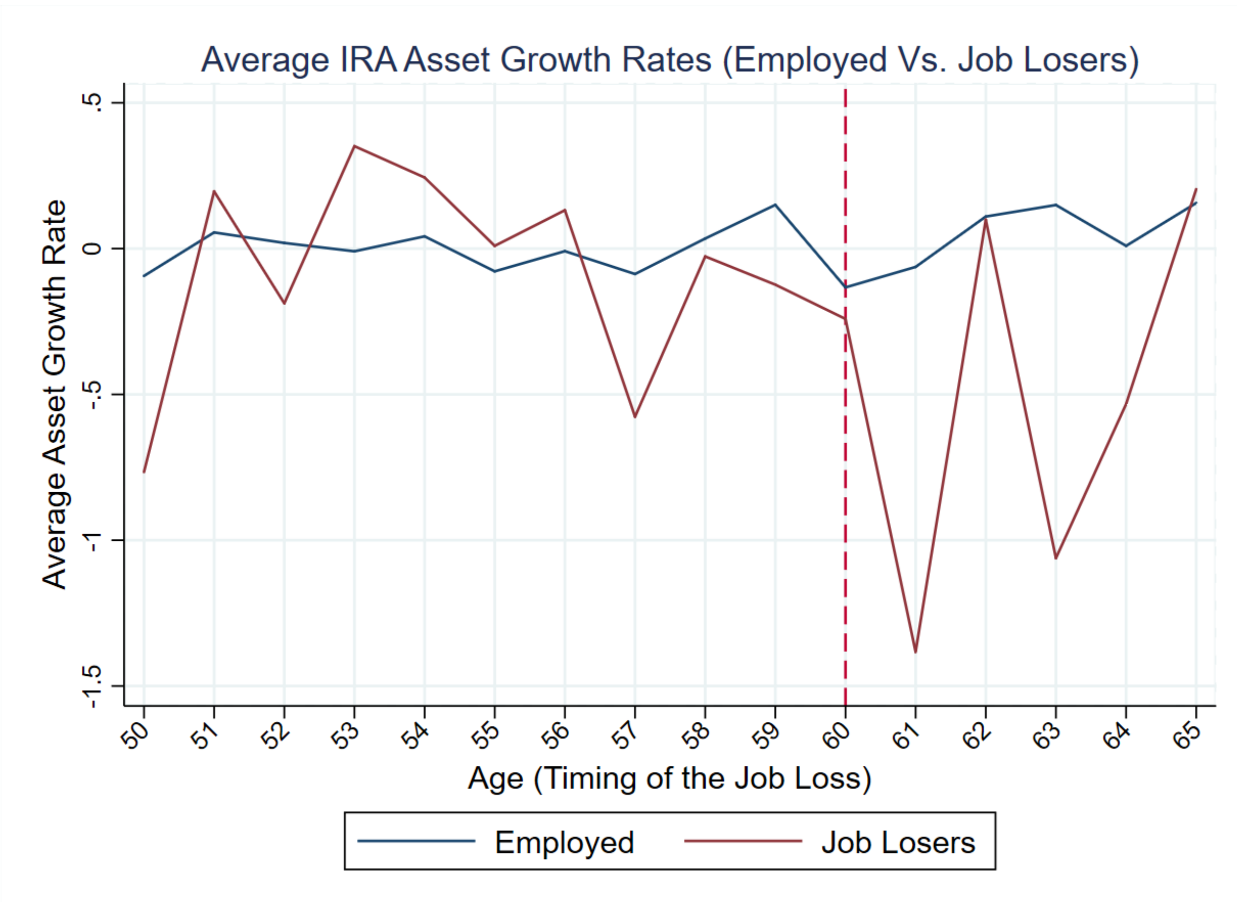
Note: The two figures plots the Social Security claiming trends produced using SIPP data for men (upper figure) and women (lower figure) separately. A large density of claiming events is observed for individuals between their 62nd and 63rd birthday, followed by a smaller spike for individuals between their 65th and 66th birthday. Women are less likely to wait until the Full Retirement Age (65 for the cohorts in question). Source: Author's calculation based on the SIPP sample.

Figure A.2: The likelihood of observing a job loss event at each age: Density Analysis



Note: The figure plots the likelihood of observing a job loss event at each age estimated using specification 3. Each estimate quantifies the likelihood of observing a job loss at each age relative to the omitted category (age 54). No discontinuity is observed around the age of the change in the tax price of 401(k) pensions, 55. This result alleviates the concern about the possibility of policy-induced job separations at the age cutoff 55.

Figure A.3: Average Growth Rates of IRA assets following a Job Loss at Different Ages compared to employed workers



Note: The figure plots the average growth rates of assets held in Individual Retirement Accounts IRAs at each age net of person fixed effects, for the job losers and the employed. The treatment group (red line) is the average IRA asset growth rates for the workers who experienced a layoff at each age. The control group (blue line) consists of the average growth rates for the population that didn't experience a layoff at that age. The dashed vertical line indicates age 60 at which the tax-price of accessing IRA accounts changed from 10% to zero penalty. Immediately after the removal of the penalty, job losers initiate large IRA asset withdrawals.

Appendix B

Supplemental Material to Chapter 2

I 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.[1] 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:

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

1. 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.

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 B.5 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 B1 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 support the hypothesis of a credit-induced decline in home values in the undamaged regions after the storm.

II 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).

III Appendix Tables and Figures

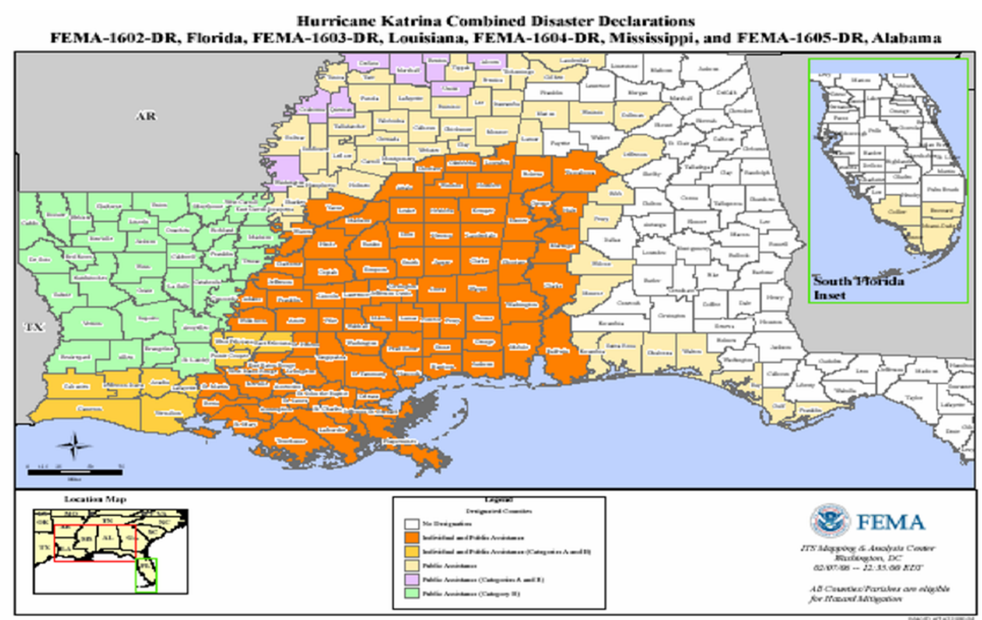
Table B1: Post-Katrina Increase in Interest rates in the financially linked MSAs relative to the weakly linked MSAs (Outside of disaster areas)

	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

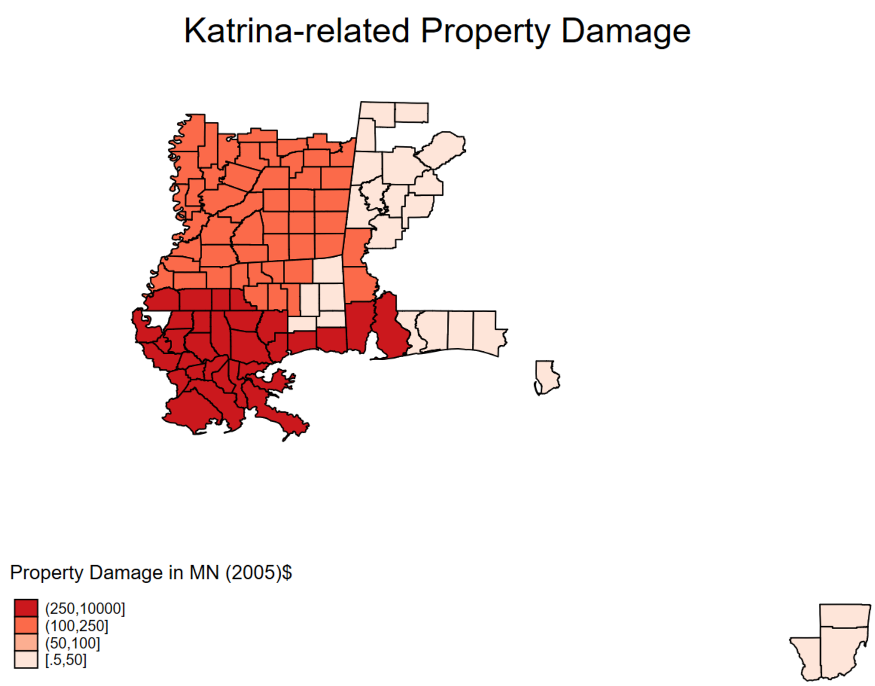
Note: The estimate presented at this table quantifies the average Contract interest rate differential between metropolitan areas based on the strength of their financial linkages to Katrina areas, after the storm compared to before the storm. The period of study is 2001:2009. The dependent variable is 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 B.1: 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 and Dermisi (2007) and FEMA's Disaster Declarations Summary File.

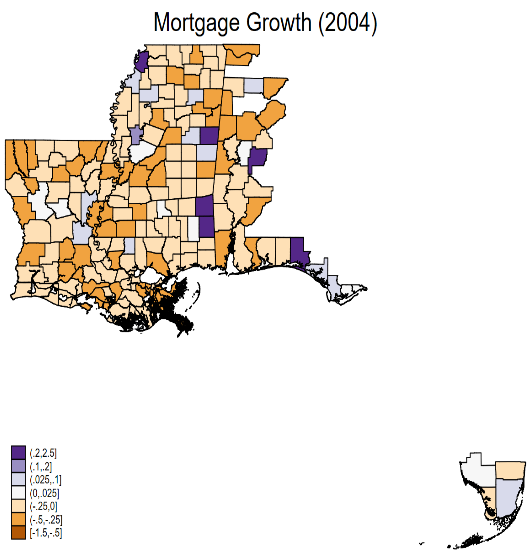
Figure B.2: Property Damage due to Katrina



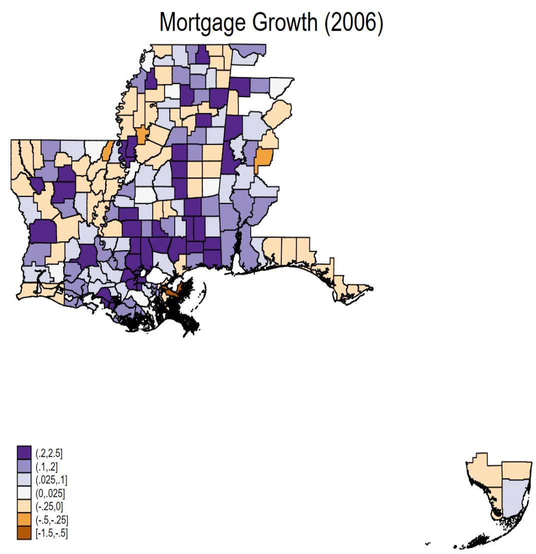
Note: Property Damage reported by the Spatial Hazard Events and Losses Database for the United States SHELDUS maintained by Arizona State University and disaggregated at the county level. The total property damage in the areas considered amounts to $74.15 BN (2005 $).

Figure B.3: 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)

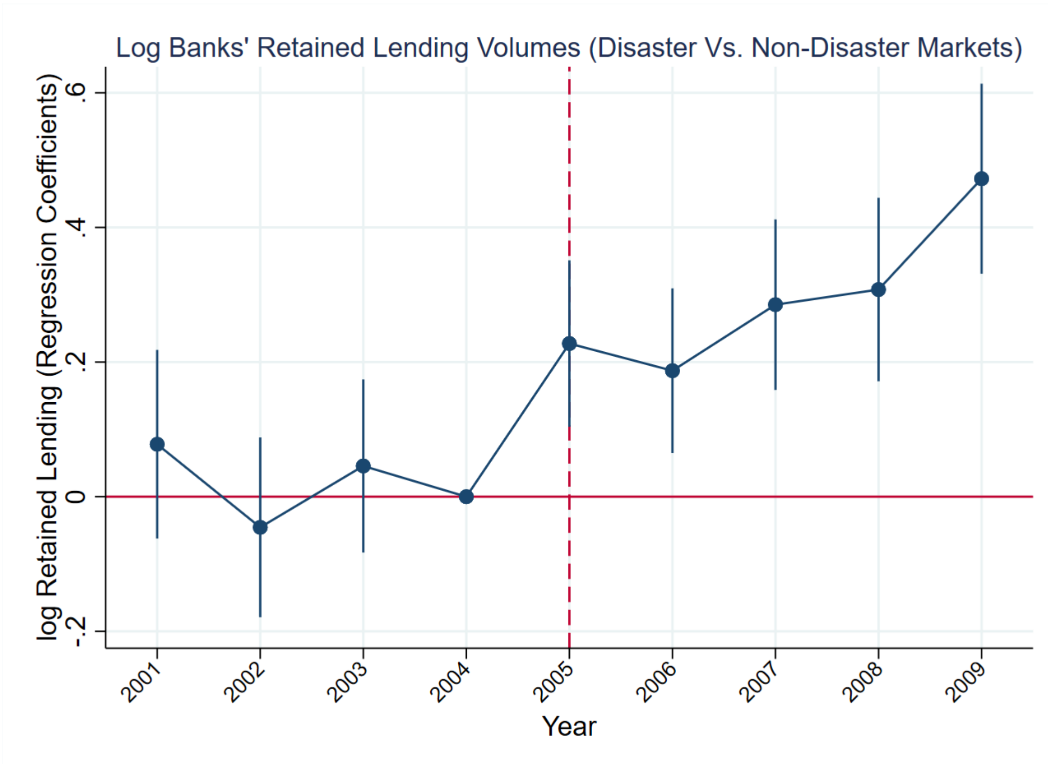


Booming local mortgage markets after Katrina (2006)



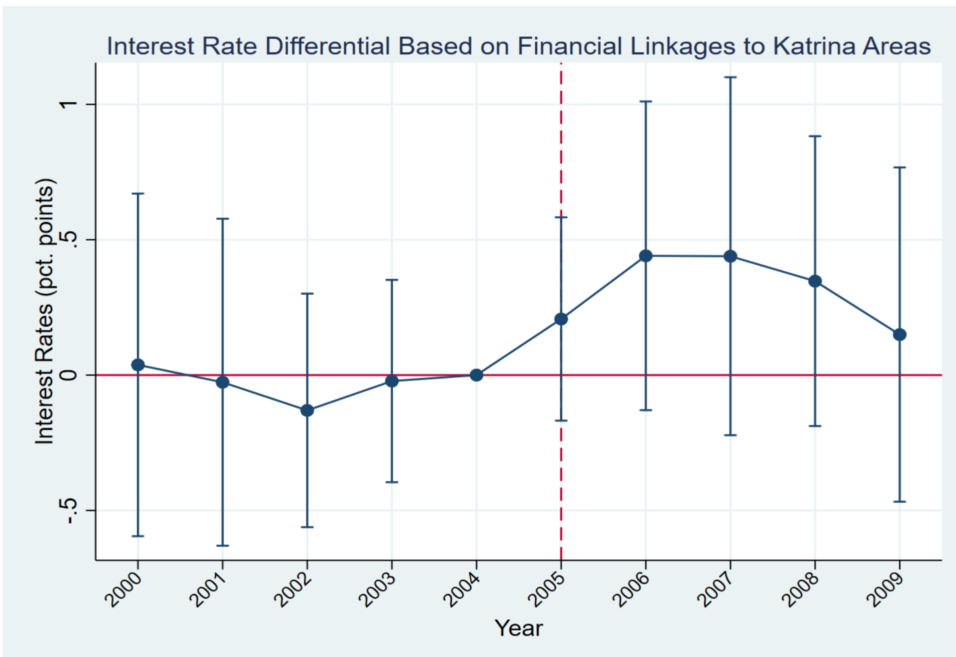
Note: This figure makes a simple comparison of mortgage growth rates of total mortgage origination volumes per county before and after the storm in disaster areas. Orange areas reflect weak mortgage growth while the purple indicates high growth rates of mortgage origination volumes. Immediately after 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 B.4: 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 B.5: 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.

IV List of CBSA included in the CBSA-Level Analysis:

1. Akron, OH
2. Albany-Lebanon, OR
3. Albany-Schenectady-Troy, NY
4. Albuquerque, NM
5. Altoona, PA
6. Ames, IA
7. Anchorage, AK
8. Ann Arbor, MI
9. Appleton, WI
10. Asheville, NC
11. Atlantic City-Hammonton, NJ
12. Bakersfield, CA
13. Baltimore-Columbia-Towson, MD
14. Battle Creek, MI
15. Bay City, MI
16. Beckley, WV
17. Bellingham, WA
18. Bend, OR
19. Billings, MT
20. Binghamton, NY

21. Bismarck, ND
22. Blacksburg-Christiansburg, VA
23. Bloomington, IN
24. Bloomsburg-Berwick, PA
25. Boise City, ID
26. Boulder, CO
27. Bowling Green, KY
28. Bremerton-Silverdale-Port Orchard, WA
29. Buffalo-Cheektowaga, NY
30. Burlington, NC
31. Canton-Massillon, OH
32. Carbondale-Marion, IL
33. Carson City, NV
34. Casper, WY
35. Cedar Rapids, IA
36. Chambersburg-Waynesboro, PA
37. Champaign-Urbana, IL
38. Charleston, WV
39. Charleston-North Charleston, SC
40. Charlottesville, VA
41. Cheyenne, WY

42. Chico, CA
43. Cleveland-Elyria, OH
44. Coeur d'Alene, ID
45. Colorado Springs, CO
46. Columbia, MO
47. Columbia, SC
48. Columbus, IN
49. Columbus, OH
50. Corvallis, OR
51. Danville, IL
52. Decatur, IL
53. Denver-Aurora-Lakewood, CO
54. Des Moines-West Des Moines, IA
55. Dover, DE
56. Dubuque, IA
57. Durham-Chapel Hill, NC
58. East Stroudsburg, PA
59. Eau Claire, WI
60. El Centro, CA
61. Elizabethtown-Fort Knox, KY
62. Elkhart-Goshen, IN

63. Elmira, NY

64. Enid, OK

65. Erie, PA

66. Eugene-Springfield, OR

67. Fairbanks, AK

68. Farmington, NM

69. Fayetteville, NC

70. Flagstaff, AZ

71. Flint, MI

72. Florence, SC

73. Fond du Lac, WI

74. Fort Collins, CO

75. Fort Wayne, IN

76. Fresno, CA

77. Gettysburg, PA

78. Glens Falls, NY

79. Goldsboro, NC

80. Grand Island, NE

81. Grand Junction, CO

82. Grand Rapids-Kentwood, MI

83. Grants Pass, OR

84. Great Falls, MT
85. Greeley, CO
86. Green Bay, WI
87. Greensboro-High Point, NC
88. Greenville, NC
89. Greenville-Anderson, SC
90. Hanford-Corcoran, CA
91. Harrisburg-Carlisle, PA
92. Harrisonburg, VA
93. Hickory-Lenoir-Morganton, NC
94. Hilton Head Island-Bluffton, SC
95. Idaho Falls, ID
96. Indianapolis-Carmel-Anderson, IN
97. Iowa City, IA
98. Ithaca, NY
99. Jackson, MI
100. Jacksonville, NC
101. Janesville-Beloit, WI
102. Jefferson City, MO
103. Johnstown, PA
104. Joplin, MO

105. Kahului-Wailuku-Lahaina, HI

106. Kalamazoo-Portage, MI

107. Kankakee, IL

108. Kennewick-Richland, WA

109. Kingston, NY

110. Kokomo, IN

111. Lake Havasu City-Kingman, AZ

112. Lancaster, PA

113. Lansing-East Lansing, MI

114. Las Cruces, NM

115. Las Vegas-Henderson-Paradise, NV

116. Lawrence, KS

117. Lawton, OK

118. Lebanon, PA

119. Lexington-Fayette, KY

120. Lima, OH

121. Lincoln, NE

122. Longview, WA

123. Lynchburg, VA

124. Madera, CA

125. Madison, WI

126. Manhattan, KS
127. Mankato, MN
128. Mansfield, OH
129. Medford, OR
130. Merced, CA
131. Michigan City-La Porte, IN
132. Midland, MI
133. Milwaukee-Waukesha, WI
134. Missoula, MT
135. Modesto, CA
136. Monroe, MI
137. Morgantown, WV
138. Mount Vernon-Anacortes, WA
139. Muncie, IN
140. Muskegon, MI
141. Napa, CA
142. New Bern, NC
143. Niles, MI
144. Ocean City, NJ
145. Ogden-Clearfield, UT
146. Oklahoma City, OK

147. Olympia-Lacey-Tumwater, WA

148. Oshkosh-Neenah, WI

149. Owensboro, KY

150. Oxnard-Thousand Oaks-Ventura, CA

151. Parkersburg-Vienna, WV

152. Peoria, IL

153. Phoenix-Mesa-Chandler, AZ

154. Pittsburgh, PA

155. Pocatello, ID

156. Provo-Orem, UT

157. Pueblo, CO

158. Racine, WI

159. Raleigh-Cary, NC

160. Rapid City, SD

161. Reading, PA

162. Redding, CA

163. Reno, NV

164. Richmond, VA

165. Riverside-San Bernardino-Ontario, CA

166. Roanoke, VA

167. Rochester, MN

168. Rochester, NY
169. Rockford, IL
170. Rocky Mount, NC
171. Sacramento-Roseville-Folsom, CA
172. Saginaw, MI
173. St. Cloud, MN
174. St. George, UT
175. Salem, OR
176. Salinas, CA
177. Salt Lake City, UT
178. San Diego-Chula Vista-Carlsbad, CA
179. San Jose-Sunnyvale-Santa Clara, CA
180. San Luis Obispo-Paso Robles, CA
181. Santa Cruz-Watsonville, CA
182. Santa Fe, NM
183. Santa Rosa-Petaluma, CA
184. Scranton–Wilkes-Barre, PA
185. Sheboygan, WI
186. Sierra Vista-Douglas, AZ
187. Sioux Falls, SD
188. Spartanburg, SC

189. Spokane-Spokane Valley, WA
190. Springfield, IL
191. Springfield, MO
192. Springfield, OH
193. State College, PA
194. Staunton, VA
195. Stockton, CA
196. Sumter, SC
197. Syracuse, NY
198. Terre Haute, IN
199. Toledo, OH
200. Topeka, KS
201. Trenton-Princeton, NJ
202. Tucson, AZ
203. Tulsa, OK
204. Utica-Rome, NY
205. Vallejo, CA
206. Vineland-Bridgeton, NJ
207. Visalia, CA
208. Walla Walla, WA
209. Waterloo-Cedar Falls, IA

210. Watertown-Fort Drum, NY
211. Wausau-Weston, WI
212. Wenatchee, WA
213. Wichita, KS
214. Williamsport, PA
215. Wilmington, NC
216. Winston-Salem, NC
217. Yakima, WA
218. York-Hanover, PA
219. Yuba City, CA
220. Yuma, AZ

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Vita

Mr. Elsadek Mahmoudi started his doctoral journey in economics in Fall 2015 having in mind public economics and tax policy as main fields. Throughout his coursework, he developed additional interests in mortgage markets, banking and consumer finance. Intellectual curiosity, interactions with multiple faculty members and a wide range of readings helped him broaden his research portfolio. He was finally able to present a dissertation combining topics in public and financial economics.

Throughout his PhD studies, Mr. Elsadek Mahmoudi was awarded the National Bureau of Economic Research (NBER) pre-doctoral fellowship on the Economics of an Aging Workforce. This award was a turning point in his doctoral studies. It raised his expectations, his standards and gave him significant exposure and recognition. Mr. Elsadek Mahmoudi also joined the International Monetary Fund (IMF) for a competitive internship in summer 2018. His research was presented and scheduled for presentation at multiple top economics, finance and real estate conferences. Just before the completion of his degree, he received an invitation to revise and resubmit his paper on pension savings for the Journal of Public Economics. He was also selected as a finalist for BlackRock Applied Research Award for his paper on the propagation of local credit shocks.

Prior to his PhD studies, Elsadek Mahmoudi was a diplomat representing the government of Egypt in trade and finance negotiations. Having a practitioner's exposure to the field of economics encouraged him to acquire the necessary theoretical and empirical tools to make a contribution to the field.