Local Labor Market Shocks and Residential Mortgage Payments: Evidence from Shale Oil and Gas Booms

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Abstract

Understanding how changes to local labor market conditions impact household spending and savings decisions is a central topic in labor economics. To investigate the dynamics of this relationship, we examine mortgage payment choices of homeowners who purchased property in areas that later experienced a positive shock to local economic conditions via the shale oil and gas boom. Using a large loan-level dataset with detailed information on mortgage originations and monthly payments, we find that borrowers with properties located in areas with shale oil and gas booms experienced a 6% reduction in the probability of missing a mortgage payment.

1 Introduction

After many years of declining crude oil production in the United States, recent technological developments have made the extraction of previously inaccessible energy resources feasible. Specifically, the advent of horizontal drilling and hydraulic fracturing techniques have enabled the exploration and production of oil and gas from "shale" geological formations, and lead to significant new drilling activity over the past decade. Contemporaneously, widespread declines in residential housing values and sharp increases in mortgage default rates in 2007-2009 were a central component of the Great Recession. Notably, in the midst of the Great Recession, the technological innovations that enabled shale oil and gas extraction provided a catalyst for an economic "boom" to clearly specified local areas where these previously inaccessible resources could now be profitably extracted. This research focuses on how this natural resource boom impacted local residents of areas where these resources were extracted. Specifically, we examine the impact of shale oil and gas discovery on long-term residents of six geographic areas that have the geological formations that allow for shale oil and/or gas extraction, namely: *Bakken*, *Eagle Ford*, *Haynesville*, *Marcellus*, *Nibabrara*, and *Utica*.[1] We estimate the impact of the shale boom on mortgage payment activity of individuals who purchased property in one of these areas prior to the natural resource discovery. Specifically, we examine the impact of the shale boom on the probability of mortgage default during a time period where aggregate default rates nationwide were sharply increasing. For the average homeowner, their house is typically the largest asset on their household balance sheet, typically making up over two-thirds of a household's wealth (Iacoviello, 2011). Additionally, for homeowners with outstanding mortgages, this loan is typically their largest financial obligation.

Using a difference-in-differences framework, we find that borrowers with properties in counties with shale oil and gas resources experience, on average, a 6% reduction in the probability of mortgage default as compared to similar mortgages in non-shale areas after the boom began. This reduction in the probability of default reaches a maximum of approximately 7%-9% in 2009, during the peak of the shale boom, and attenuates to approximately a 1%-2% difference in default probabilities by the end of 2014. These results are robust to choice of control group, risk categories, alternate definitions of default, and placebo tests. Overall, our results provide evidence of a significant positive economic impact of shale oil and gas booms to long-term local residents where these natural resources are located.

[1] These areas are definitions are based on EIA (2015). The *Permian* basin located in western Texas was not included in this analysis because sufficient data on mortgages were not available.

1.1 Economic Impact of Oil and Gas Booms

Modern crude oil production began in 1859 with Drake Well, five miles south of Titusville, Pennsylvania and began a period of rapid growth and expansion in the oil industry (Yergin, 1999). As people from all income ranges around the country began "pushing back the night" for the first time with inexpensive fuel that could be used for lighting homes, oil became an almost instant necessity. So began the age of oil that quickly spread throughout the world.

For almost a century the U.S. experienced consistent increases in oil production. But in 1970, this age of increasing domestic production reached its end and for the first time in U.S. history production began a period of decline that continued for the next four decades. However, over the last ten years, the oil landscape has changed both suddenly and dramatically as illustrated in Figure 1. By 2007, after a long period of declining production in the U.S., a technological breakthrough allowed "shale" oil and gas extraction to become economically viable for the first time in history; the "shale boom" was underway.[2] Through a combination of horizontal drilling and hydraulic fracturing (informally referred to "fracking") the trend in oil production reversed itself and the U.S. has since experienced increases in production. By the end of 2014, the U.S. was observing crude production similar to the historic levels achieved during "peak oil" of the 1970s (EIA, 2014).[3] There has been a growing body of work that utilizes this plausibly exogenous shock to explore a variety of economic outcomes.

More generally, there is a growing literature on the economic impact of fossil fuel based shocks to economic activity; and this literature has seen a resurgence due to the recent shale boom. Black et al. (2005) examines the impact of the coal boom and subsequent bust in the 1970s and 1980s on local labor markets and finds that in addition to increases in employment in the coal sector, employment increased in non-coal sectors as well. More recently, Allcott and Keniston (2014) utilize historical oil and gas production data in the U.S. since the 1960s and find that booms increase both employment and wages of local workers, and these increases are not just restricted to the oil and gas sectors. Most recently, Feyrer et al. (2015) finds that the shale boom specifically created significant economic shocks to local labor markets. Every million dollars of oil and gas extracted is estimated to generate $243,000 in wages, $117,000 in royalty payments, and 2.49 jobs within a 100 mile radius. In total, the authors estimate that the shale boom was associated with 725,000 jobs in aggregate

[2]For the main empirical specifications in this research, the shale boom will begin in 2007 consistent with the time that EIA began tracking shale production (EIA, 2015). We will consider the specific timing of the treatment in an alternative specification.

[3]By about mid-2015, the shale boom was slowing substantially due to the sharp drop in the oil price seen worldwide. This research will consider data until the end of 2014.

and a 0.5 percent decrease in the unemployment rate during the Great Recession.

Thus, shocks to both the coal and oil and gas sectors have been found to impact the local economy, not only by creating jobs within the respective fossil fuel sector but also spilling over into other sectors within the economy. This is important, because if these shocks only provide increases in employment and wages in a specific sector, and that sector makes up a relatively small share of the local economy, then it is questionable whether or not the shock will be of interest to economists who want to use these shocks to generally understand how plausibly exogenous overall shocks to employment and wages impact outcomes of interest.

Because these shocks have been shown to have economy wide labor market implications, some studies have used natural resource shocks as an instrument for local labor market conditions. Black et al. (2002) exploits the coal boom and bust in the 1970s-1980s as a shock to the value of labor market participation to test the impact of earnings on Social Security Disability Insurance (DI) payments and participation, finding a negative relationship between earnings growth and growth in the DI program. Acemoglu et al. (2013) take advantage of variation in oil prices interacted with local oil reserves to estimate the impact of rising income on health expenditures.

Additionally, there has been interest in how shale booms impact local financial conditions. Gilje (2012) treats the shale boom as a catalyst to an exogenous increase in local bank deposits and local credit supply and finds that counties with large shale booms also experience a large increase in new business establishments that are reliant on external bank financing. This effect is particularly strong in counties that are dominated by small local banks. Similarly, Gilje et al. (Forthcoming) exploit the shale boom to show that bank branch networks continue to play an important role in financial integration by demonstrating that banks with branch exposure to shale booms also increase mortgage lending in non-boom counties. Vachon (2015b) exploits the Bakken oil boom in North Dakota and finds that the oil boom led to large increases in the sales and income tax bases at the local level.

There are a number studies that have specifically focused on the impact of oil and gas development on local real estate markets, but this literature has been largely focused on the negative impact of drilling wells in close proximity to residential properties. Boxall et al. (2005) examines the impact of oil and gas facilities on rural residential property values in Alberta, Canada and finds that property values are negatively correlated with the number of sour gas wells and flaring oil batteries. Using hedonic pricing models, Muehlenbachs et al. (2015) finds that groundwater-dependent homes near oil and gas wells in the Marcellus shale (located in Pennsylvania) experience decreases in housing values, while similar homes that receive water from pipes experience increases in housing values likely associated with lease payments. Gopalakrishnan and Klaiber (2014) estimate a hedonic pricing model for homes near Pittsburgh, PA (also in the Marcellus shale region) finding that homes in close proximity to wells experienced decreases in housing values. While not a study on shale specifically, Boxall et al. (2005) finds that houses located near wells emitting hydrogen sulfide (that smells like rotten eggs) had a negative impact on property values in Alberta, Canada. All of these studies that examine local real estate markets have focused primarily on the negative impact of drilling on homes in close proximity to drilling activity, the "not in my back yard" (NIMBY) mantra that is commonly used in this context.

To date there is limited work on the impact of drilling activity on housing markets beyond properties directly impacted by natural resource extraction. One notable exception to this trend is recent work by Shen et al. (2015) in examining the impact of the shale oil and gas boom on mortgage markets in Pennsylvania. The authors examine default probabilities specifically for loans within the state of Pennsylvania and find no evidence that nearby "fracking" triggers mortgage default, but do find evidence that the economic activity associated with the boom can decrease the probability of mortgage default for new mortgages that originate after the boom begins.

There are two plausible channels through which an economic boom may decrease mortgage delinquency rates. The first channel is through increased earnings and employment. A number of studies have used natural resource booms as an instrument for local earnings to test the impact of earnings on a number of outcomes such as disability program participation (Black et al., 2002), health spending (Acemoglu et al., 2013) and labor migration (Vachon, 2015a). The second channel is through a plausible housing price increase. Housing prices are known to be pro-cyclical (Leamer, 2008; Davis and Heathcote, 2005). Thus, if housing values in an area are increasing, and a household finds themselves in a situation where they are unable to pay their mortgage and expect this inability to pay to extend beyond the short-term, the household with positive equity will rationally choose to sell the property instead of defaulting on the loan.

We extend the literature on the impact of natural resource booms on housing and more broadly, household financial decisions in several ways. First, instead of focusing on changes in real estate values with a hedonic pricing model like much of the previous literature (Boxall et al., 2005; Muehlenbachs et al., 2015; Gopalakrishnan and Klaiber, 2014), we examine individual households' mortgage payment decisions, specifically focusing on the probability of mortgage default. We hypothesize that probability of mortgage default will decline for households in these areas compared to similar households in other parts of the country with no shale boom.

Second, instead of focusing on a single area that experienced a boom (Shen et al., 2015), we take advantage of the fact that the shale boom is unique in that it impacted multiple areas across the country that happened to be located on specific geological formations. Therefore we are able to analyze the effect of the boom on six clearly defined geographic areas. These shale plays include *Bakken*, *Eagle Ford*, *Haynesville*, *Marcellus*, *Niobrara* and *Utica*. We identify individual mortgages that originated in counties with shale oil and/or gas activity prior to the technology shock that enabled the profitable extraction of these resources and track their payment activity until the end of 2014, or until the mortgage is terminated. Thus, this is the most comprehensive study on the impact of shale on housing markets across different shale plays.

Finally, we employ a large detailed data set with national coverage, BlackBox Logic (BBx), which provides information on over 90 percent of the privately securitized mortgages in the U.S. which includes origination information on over 20 million unique single-family residential mortgages.[4] By using a nationwide sample of loans we can select a control group of loans that are not in geographic proximity to shale oil and gas extraction to mitigate concerns about spillover effects. We observe information on individual loans at origination as well as detailed monthly payment histories of each mortgage. Therefore, we know if and when a household has missed a mortgage payment as well as the current outstanding balance on the loan. We match individual loan payments to counties that experienced increases in oil and gas activity from 2007 to 2014 compared to similar loans in similar counties across the U.S. that did not experience a shale boom.[5]

[4] Agency securitized loans (e.g. Freddie Mac or Fannie Mae) and loans held on lenders' balance sheets are not privately securitized and therefore not included in the data.

[5] For purposes of this research, we consider post 2007 as the treatment time period consistent with EIA (2015). We observe mortgages originated as early as 2000 and follow these mortgages through termination (due to default or prepayment) or the end of 2014, whichever comes first. Due to a large drop in the oil price in 2015, the shale boom largely ended in mid-2015. Therefore, studying the time period from 2007 to 2014 is likely the most appropriate definition of the "boom" time period. We will consider the specific timing of the treatment in an alternative specification.

2 Data, Variables, and Summary Statistics

2.1 Data

We use loan-level information for properties located in the shale (treated) areas compared to properties in non-shale (control) areas; we observe characteristics about the loan and the borrower at origination as well as the time series of monthly payments until the loan is terminated. We begin to observe monthly payments after the loan is placed into a mortgage backed security.[6] A loan can leave our sample for three reasons: the loan is terminated by the lender for lack of payment (severe default, foreclosure, and/or bankruptcy), the borrower prepays the remaining balance of the mortgage (e.g. lump sum prepayment, refinancing the property, or selling the property before the mortgage is repaid in full), or the original contract period of the loan ends. To avoid the potentially confounding effects of changes to the local real estate market after the beginning of the shale boom, we only include observations from loans that were originated prior to the discovery of shale oil and gas in a given area. Therefore, we are considering changes in mortgage payment activity on loans that originated before the shale boom began.

Loan-level data used in our analysis is from BlackBox Logic, LLC (BBx).[7] BBx contains information on over 20 million loans and includes over 900 million monthly remittance records as of December 2014. This proprietary mortgage database covers over 90 percent of non-agency residential securitized loans including prime, alt-a, and subprime loans. This dataset provides both characteristics of each loan at origination as well as monthly payment records.

For this study, only first-lien,[8] single family,[9] owner occupied properties[10] that have fully-amortizing loan terms are included in our sample. Additionally, we restrict our sample to new purchase loans; that is we exclude loans with the stated purpose of refinancing. Furthermore, we include only loans that originated between 2000 and 2006, before the shale boom began.[11] We observe the payment activity of these loans on properties located in the treatment areas until the end of 2014, or until the mortgage is terminated, whichever occurs

[6] There is, on average, a three month lag between loan origination and securitization.

[7] Detailed BBx data information is available at http://www.bbxlogic.com/data.htm.

[8] We look at only first-lien loans because a first mortgage is, by and large, the biggest loan against the property. Additionally, we are unable to connect the second lien loans we may observe in our dataset to the companion first lien against that property, since all information about the loan is attached to a unique loan identifier, not a property identifier. The exclusion of second lien loans, which are typically much riskier than first lien loans, likely understates the magnitude of our results.

[9] We exclude multifamily properties that are likely owned by an investor.

[10] We exclude investment properties or vacation homes as these are not the focus of our analysis.

[11] Prior to 2000, we do not have a sufficient sample size of treated loans to observe.

first, and compare them to the payment choices of loans outside of the treatment areas.

2.2 Control and Treated Areas

EIA (2015) provides a list of counties that are located within each shale play. We classify counties that are located within the *Bakken*, *Eagle Ford*, *Haynesville*, *Marcellus*, *Niobrara* and *Utica* plays as treated areas. Figure 2 shows a map of where these shale plays are located.[12] We consider all available fully-amortizing, first-lien, purchase mortgages on single family, owner-occupied properties originated between 2000 and 2006 located in these shale counties as our treatment group. In order to reduce the risk of our results being contaminated by spillover effects, mortgages on properties located in counties that are in states with shale activity, but that themselves do not contain shale oil and/or gas activity were removed from the list of potential control areas. In addition, states that directly border counties with shale activity were also removed from the potential control group.[13] For our main specifications, we employ propensity score matching to identify a control group of loans based on all observable origination characteristics from the population of mortgages in non-shale areas in our sample as well as employment and average wages in the counties for which these loans are located.[14] In other words, we find a corresponding "control" loan for every loan originated in a shale area that has (a) similar mortgage characteristics and (b) is located in a county that has a similar labor force size and similar average wages. As a robustness check, we choose 20 control groups randomly sampled from the entire universe of loans that originate in the pre-shale time period.[15] As we will show, estimated treatment effects are robust to different choices of control group, empirical specifications, and placebo tests.

2.3 Variables

Mortgage default is the dependent variable of interest. For robustness, we consider two alternative definitions referred to as "default" and "mild default." Mortgage default results

[12]This map is based on the counties identified in EIA (2015). The Permian region, while included in the map, was excluded from the analysis because there were not a sufficient number of loans in these rural areas for analysis.

[13]After applying these criteria, the potential control group comes from loans in the following twenty-nine states; AL, AZ, CA, CT, DE, FL, GA, HI, ID, IL, IN, IA, ME, MI, MN, MS, MO, NV, NH, NJ, NC, OK, OR, RI, SC, TN, VT, WA, and WI.

[14]County level employment and average wage data is from Census provided Quarterly Workforce Indicators (QWI).

[15]Simply pooling all mortgages nation-wide into a sample was not possible due to computing constraints, as it includes more than 900 million remittance records.

from the borrower not paying the contractually obligated monthly payment in a timely manner. For each loan, we observe a time series of monthly payment records and therefore can observe when an individual borrower misses one or more payments. Missing a single payment could be a reflection of a short term liquidity problem, or even simply forgetfulness on the part of the borrower. However, missing more than one payment in a row is indicative of a more serious financial problem. We will consider both mortgages that are just one month behind as well as mortgages with multiple missed payments.

First, we create a binary variable for default for a given loan, i, observed in time period, t, in which $default_{it}=1$ if the loan is 90 or more days delinquent at the time of observation. If the borrower later makes sufficient back payments, i.e. they "catch up" on their payments, the loan can be reclassified in later periods ($default_{it}=0$). We would expect loans in areas that experienced a shale boom to have a reduced probability of default as compared to similar mortgages in areas that have no shale discoveries. Next, we construct another binary variable for a less stringent definition of default. Instead of using 90 days delinquency as our threshold, we restrict our definition of default to mortgages that are 30 days or more delinquent, that is the borrower is one or more months behind on their mortgage payments. This is referred to as *mild default*.

In all specifications, we include several control variables that are standard in the real estate finance literature. First, we construct a dummy variable for the loan term to control for differences in longer and shorter term loans. The most common loan terms are 30 year and 15 year mortgages. We also observe other loan terms, such as 10, 20, and 40 year loans. We create a dummy variable for loans 30 year terms or longer. Previous studies have found that compared to 30 year loans, 15 year loans have a lower probability of default (Quercia and Stegman, 1992) and we expect our results will be consistent with these earlier findings.

We also control for the type of loan; that is, whether the loan a fixed rate mortgage (FRM) or adjustable rate mortgage (ARM). In addition, we include a continuous variable for the current interest rate on each loan. By definition, for FRM loans, the interest rate is determined at origination and remains constant for the entire life of the mortgage. For ARM loans, the interest rate is adjusted during the life of the loan and therefore can vary over time for a specific loan. Typically a ARM borrower receives a rate at origination below that of a comparable fixed rate loan and the interest rate is locked in for a set, relatively short, period. At the end of the period, the interest rate resets according to a predetermined formula that is a function of current market rates. We control for initial leverage of the loan at the time of origination through the initial loan to value ratio (*LTV at origination*). This ratio relates the initial balance of the mortgage to the purchase price of the property. For example, a $100,000 home purchased with a $20,000 down payment and therefore a $80,000 loan would have a LTV ratio of 0.8. All else equal, we would expect loans with high LTV ratios to have an increased risk of default.

We control for differences in borrower credit quality by including a continuous variable for FICO credit score at origination. These scores are a measure of borrower credit risk; specifically, FICO scores give an indication of the likelihood of a negative credit event for a borrower in the next year. Credit scores are reported in the U.S. by the three major credit bureaus, Experian, Equifax and TransUnion and typically range from a very poor score of 400 up to 850, which corresponds with a very low risk borrower. For ease of interpretation in our regression models, we scale the FICO variable by dividing the borrower's FICO score by 100. We observe the FICO score of each mortgage at origination and expect this variable is negatively associated with mortgage default as has been shown in previous literature (Mester, 1997; Demyanyk and Hemert, 2011).

Finally, we include a series of fixed effects to control for additional unobservable loan heterogeneity. We include fixed effects for the month the loan is observed, the year the loan is observed, the year the loan is originated, and the servicer assigned at origination.[16]

2.3.1 Summary Statistics

Summary statistics are presented for each of the six "shale plays" and their corresponding propensity score matched control groups in Table 1. Overall, our sample consists of 31,954 treated loans across all of the shale plays, corresponding to 1,681,336 monthly payment observations. By design the summary statistics on the origination characteristics for treated and control group are almost identical.[17] Overall, the average FICO score for our sample is 650 in the treated group and 649 in the control group. Although there is no universally accepted cutoff for subprime borrowers' credit scores, a commonly quoted threshold for a subprime FICO score in this period is 620, making our sample, on average, above the threshold for subprime lending. There is variation in average credit scores across the plays, ranging from an average of 629 for the treated group of loans in Haynesville to an average of 674 for the treated group of loans in Niobrara.

[16]We individually control for all servicers that service 1% or more of the total volume of loans nationwide in our sample. This construction results in the creation of 18 dummy variables, one for each large servicer, accounting for over 70% of the sample. All other smaller servicers are lumped together in a single category.

[17]We conduct our propensity score match on origination characteristics, so the total number of loans in both the control and treated groups are the same, but the number of payment observations is different.

Overall, the loan to value ratio for the sample is about 85% for both the treated and control groups, indicated that on average, borrowers made a 15% down payment at the point of loan origination. Loans on properties in Niobara have the lowest average LTV (82%) while loans on properties Utica has the highest (88%). Adjustable rate mortgages (ARMs) make up 45.8% of our total treated population and 44.3% of the propensity score matched control group. The remainder of loans in the sample are fixed rate mortgages (FRMs). There is variation in the ARM portion of the mortgage market across our individual treated areas, ranging from 32.7% in Eagle Ford to 53.0% in Niobrara. In our sample, 30 year or longer mortgages are by far the most common loan term (96%), and this is consistent across all shale plays. Although we do not match on the loan's current interest rate when creating our sample (interest rate can vary after origination for adjustable rate loans), the current interest rate is about 7.4% to 7.5% in both the control and treated areas.

Our summary statistics for our outcomes of interest show both default and mild default is lower in the treated areas than the control areas. This is true overall as well as in five of the six shale plays. Pooled across all time periods and geographic areas, 16.3% of the treatment group observations have a severe default versus 20.3% for the control group. These differences are similar in magnitude using our mild default measure; 27.7% of the treatment group observations have a mild default versus 31.4% of observations in the control group.

Of course, these summary statistics only provide a snapshot over the entire sample period from 2000 to 2014. Figure 3 illustrates the mortgage default and mild default rate in shale areas compared to the propensity score matched control groups to compare changes in the two groups before and after the shale boom began. As can be seen, the two groups have relatively similar levels of default and mild default before 2007, when the shale boom began. But after 2007, there is a divergence of default rates for loans in shale areas compared to non-shale areas. In particular, mortgages in treated areas experienced significant decreases in the probability of both mortgage default and mild default relative to control group mortgages.[18]

[18]Note that these mortgages originated between 2000 and 2006 and therefore these should not be interpreted as representative of all outstanding mortgages in the U.S.. Furthermore, because the earliest date that these mortgages could have originated was January of 2000, the default rate at the very beginning of these samples is very close to zero. There are a few key drivers of this low default rate early in the period. In 2000, the only loans that are observed have been originated that year, so the sample size is relatively small. Additionally, in general, it is very uncommon for a mortgage to immediately default, unless the loan was improperly underwritten. In general, absent large price declines that wipe out borrowers' equity, there is a non-linear relationship between loan age and default. Default is low in initial periods, peaks in year 3-5 of the loan, and then declines as the borrower builds equity in the property (von Furstenberg, 1969; Campbell and Dietrich, 1983). See Appendix Tables A1 to A6 for similar graphs corresponding to each shale area.

3 Empirical Strategy

As a first empirical test, we will consider two "cohorts" of mortgages; specifically mortgages that were originated in 2006 and those mortgages that were originated in 2005. That is the year before and two years, respectively, before the shale boom began in 2007. For each loan in a shale area, we conduct a propensity score match only from other loans nationwide that also originated within that year. These propensity scores are based on both loan characteristics at origination and county level labor market conditions in the pre-treatment time period. Specifically, loan level origination characteristics include the appraisal value of the home, LTV ratio, original interest rate, FICO score, whether the loan had a term longer or shorter than 30 years, and whether the mortgage is an ARM or FRM. County level employment and average earnings are observed in these respective years (QWI). Thus, these control mortgages originated in the same year, have similar origination characteristics, and are located in a county with a similar labor market size and average earnings.

We then observe the first occurrence, if ever, for which each mortgage experienced default (or mild default) and test whether mortgages in shale counties are less likely to have gone into default during, or before, a given year. This is illustrated in equation (1),

$$d_{i,c} = \alpha + \beta Shale_c \tag{1}$$

In this first empirical specification, we are not using the full panel of payment information. For all loans in the 2005 cohort (a total of 24,686 loans) we estimate this model for each year 2007– 2013. In this specification, $d_{i,c}$ is an indicator variable for whether the mortgage in county c (that is either a shale or non-shale county), has ever entered into default during or before a given year. Then, we repeat this analysis for the 28,453 loans that are in the 2006 cohort. Next, we expand this analysis to consider all mortgages originated in the 2000 to 2006 time period and utilize the full panel of payment history of each loan.

Equation (2) illustrates the commonly used difference-in-differences (DD) style estimation strategy used to test for the impact of shale oil and gas on mortgage default utilizing the full panel of data available.

$$d_{i,c,t} = \alpha + \delta(S_{Shale_c} \times Shale_t) + X'_{i,t}\zeta + \gamma_1 D_s + \gamma_2 D_m + \gamma_3 D_y + \gamma_4 D_o + \varepsilon_{i,c,t} \tag{2}$$

where $d_{i,c,t}$ is the outcome of interest–mortgage default–for individual mortgage i in county c in month t. S_{Shale_c} is an indicator variable corresponding to counties with shale oil and/or gas activity (i.e. the treatment group) and is zero for the mortgages not located in one of the counties with shale activity. $Shale_t$ is an indicator variable that indicates the time periods after shale activity began. All of the shale plays, and therefore counties that EIA defines to have shale activity, saw increases in drilling starting around 2007 and this drilling activity continued until the end of 2014.[19] We use a logistic regression to estimate the change in the probability of default and mild default in each shale play. For ease of interpretation, we present all results as marginal effects estimated at the means for each variable. For each model, we estimate standard errors clustered at the property zip code level.

The vector X'_{it} contains control variables that are standard in the real estate finance literature, including the term of the mortgage, whether the mortgage has a fixed or adjustable interest rate, the initial interest rate of the mortgage (that is either fixed or varies over time based on the mortgage type), the FICO score of the borrower at origination and the loan to value ratio of the loan at origination. Additionally, all estimations include fixed effects for loan servicer D_s, month of observation D_m, year of observation D_y, and year of origination D_o.

Our primary results are obtained using this DD framework; we estimate the impact of the shale boom on default (and mild default) using our propensity-score matched control group as described in Section 2.1. The estimated δ provides us with the change in default in treated areas relative to non-treated areas during the boom, while controlling for a number of loan specific covariates including the loan term, interest rate, and a number of other origination characteristics. We provide both geographically pooled estimated of this treatment effect as well as conduct separate estimations for each treated shale area.

Next, we investigate if the expected reduction in default probability for the treatment group is concentrated in a subset of borrowers. We split our sample by credit scores and initial LTV ratios–two standard non-geographic measures of risk–and repeat our DD estimation. We first divide our full sample over four FICO credit score buckets: less than 620, 621 to 680, 681 to 739, and 740 or higher. Although there is no precise industry prescribed cut-off for what is considered to be a subprime or prime loan, these buckets roughly correspond to subprime, near-prime, prime, and super-prime credit categories, respectively. Additionally, we repeat this test for different loan-to-value (LTV) buckets at the time of origination. We

[19]Of course, the exact start time of the boom varies across shale plays. In the initial specification, we include 2007 as the start date for the shale boom, but we later present the year specific estimated treatment effects by shale play (see Figure 4 and Figures A7-A12). We end the analysis at the end of 2014 for two reasons. First, our mortgage data availability only extends through the end of 2014. Additionally, in 2015 global oil prices dropped significantly, and therefore the "bust" plausibly began some time during 2015. Therefore, 2007 to 2014 is the best general time period that can be considered the "boom" or "treatment" time period.

estimate our model for each of the following LTV categories: <=80%, 80-85%, 85-90%, 90%-95%, >95%. These results will provide an idea of the type of borrowers that are most sensitive to changes in the probability of default associated with economic booms. For both tests, we estimate the regression model described in Equation 2 for each risk bucket using the complete list of controls described in the base model.

Finally, we investigate the robustness of our main results by conducting a series of tests. First, we test the sensitivity of our results to alternative control groups by repeating the baseline DD estimation 20 times for each shale play, as well as the overall universe of treated areas, using a randomly selected control group from the nationwide sample of loans in lieu of the propensity score matched sample.[20] All of these results are estimated for both definitions of default.

In addition, we employ two falsification tests. First, we implement a placebo treatment on randomly selected loans that are not located in areas impacted by the shale boom from our baseline control groups. Second, we repeat the placebo test, this time using the universe of treated loans and randomly assigning these loans to either the treatment or control group.

Next, we consider the exact timing of the treatment effect by estimating the average difference in default rates for the treated and control mortgages using Equation 3:

$$d_{i,c,t} = \alpha + \sum_{y=2003}^{2014} \delta_t (S_{Shale_c} \times D_t) + X'_{i,t}\zeta + \gamma_1 D_s + \gamma_2 D_m + \gamma_3 D_y + \gamma_4 D_o + \varepsilon_{i,c,t} \quad (3)$$

where again $d_{i,c,t}$ is the outcome of interest–mortgage default–for individual mortgage i in county c in month t. S_{Shale_c} is an indicator variable corresponding to counties with shale oil and/or gas activity (i.e. the treatment group) and is zero for the mortgages not located in one of the counties with shale activity and D_t is a dummy variable for each year from 2003 to 2014.

Consistent with all prior regressions, the vector X'_{ist} contains all control variables and all estimations include fixed effects for loan servicer D_s, month of observation D_m, year of observation D_y, and year of origination D_o. In this specification, δ_{2003}, $\delta_{2004} \ldots \delta_{2014}$ are the coefficient estimates of interest. Unlike the previous differences-in-difference estimation strategy, these coefficients simply show the estimated difference in default rates in treated and control areas after controlling for all covariates by year. In the years prior to the shale boom,

[20] Similar to the propensity score match sample, we only pull loans out of states that have no shale activity, and are not directly adjacent to a county with shale activity. Therefore, the potential control group comes from the following states; AL, AZ, CA, CT, DE, FL, GA, HI, ID, IL, IN, IA, ME, MI, MN, MS, MO, NV, NH, NJ, NC, OK, OR, RI, SC, TN, VT, WA, and WI.

we expect these coefficient estimates to be relatively small in magnitude. Once the shale boom begins, we expect that these coefficient estimates will become larger in magnitude. This will provide evidence of when the boom began (and possibly ended), for both the entire sample and for each shale area separately.

4 Results

Table 2 presents the results of the cohort analysis. For the 2005 cohort (loans originated in the calendar year 2005), loans that are located in shale areas are 1.9% less likely to default by 2007, 4.1% less likely to default by 2008, and by 2013 are about 6.2% less likely to have ever defaulted. Similarly, for the 2006 cohort, mortgages in shale areas were 3.1% less likely to default through the year 2007, about 6.7% less likely to default by 2008 and by 2013 were about 8.0% less likely to have defaulted. While specific point estimates for mild default are slightly different in order of magnitude, these pattern is the same. Each of these 28 estimated marginal effects are statistically significant at p=.01. These results show that of loans originated in the two years leading up to the boom, loans in shale counties had lower probabilities of later going into default compared to other mortgages in non-shale counties with similar origination characteristics and located in counties with a similar labor market size and average wages.

Table 3 shows main results utilizing the full panel of data available with the propensity score matched control group for both default and mild default. For the overall sample, we estimate that the shale boom is associated with a 6.1% decrease in the probability of mortgages of default. In addition, each of the six areas experienced a statistically significant decrease in the probability of mortgages default with estimated marginal effects ranging from 4.1% in Eagle Ford to 9.1% in Bakken. Similar results are observed for the less stringent 30+ day definition of default (i.e. mild default). Overall, mortgages in shale areas experience a 5.7% decrease in mild default, with point estimates in individual shale plays ranging from 4.4% in Marcellus to 9.3% in Bakken.

The mortgage specific control variables perform largely as expected. In the 90+ days default specification, borrower creditworthiness, as measured by FICO credit scores at origination, is negatively associated with default. A 100 point increase in FICO score is associated with, on average, a 8.8% reduction in the probability of default. A one point increase in the initial interest rate of the loan is associated with, on average, a 2.2% increase in the probability of default. A 30 year or longer loan is associated with, on average a 2.7% increase in the probability of default. The estimates for initial leverage are positive, but only statistically significant in three of the seven specifications. As compared to fixed rate loans, adjustable rate mortgages on average are 6.7% more likely to default and 30 year mortgages are 2.7% more likely to default. These results are similar for the 30+ days definition of delinquency; in this specification the magnitude of the effects for loan term and credit score is larger and the leverage variable is positive and statistically significant overall.

Table 4 presents results pooled across all geographic areas subset by risk category. We find a significant negative treatment effect for each of our four credit score categories. We find that the largest treatment effect of a 9.3% reduction in default probability in the 681-739 credit score bucket, closely followed by a 8.3% reduction in default probability for the 621-680 credit score bucket. These middle credit buckets, corresponding roughly to the universe of near-prime and prime borrowers in our sample, have treatment effects that are more than double those found in the lowest credit bin (-3.7%) and the highest credit bin (-4.0%). This result is intuitive; those with very high (low) credit scores have a low (high) probability of default, independent of local economic conditions; therefore the change in local economic conditions precipitated by the shale oil and gas boom has a relatively smaller marginal impact on their probability of default than those with average default risks.

Similarly, we find significant treatment effects for each of our LTV categories. However, borrowers with high leverage experience relatively smaller reductions in the their default probabilities (3.6-4.9%) as compared to the 8.3% reduction in default probability those borrowers who purchased their homes with at least 20% equity (LTV<= 80). These results provide some insight into the relative impact of the shale boom for borrowers of different risk categories, but it's important to note across the spectrum of both metrics of borrower level risk we find that the shale boom has a consistent significant negative impact on the probability of default.

Next, we test the sensitivity of our results to alternative control groups by randomly choosing 20 control groups. Table 5 shows the results for default using 20 random control groups taken from nationally sample of loans. The process of generating a random control group is performed 20 times for each of the 6 shale plays as well as 20 times for the overall sample. For each of these iterations, we estimate a treatment effect. Out of the 280 estimated treatment effects whose estimates we present in Table 5, all but one are negative and statistically significant at the p=.05 level and all but four are statistically significant at the p=.01 level. The average treatment effect across all iterations for each play ranges from 6.2% in Niabrara to 14.9% in Bakken with an average treatment effect of 8.5% in the sample pooling all 6 shale plays. Table 6 presents the same analysis for the mild default variable. These results are similar to the results for the 90+ days of delinquency specification. Overall, these results show that our main results is robust to many different selections of control groups.

Table 7 shows the results from the first placebo test, that randomly assign loans in actually treated areas into either the treatment or control group. We expect to find no consistent effect of this placebo treatment effect on either default or mild default. Across the 14 regressions that span both default definitions and each shale play, eight of the estimated treatment effects are negative while the remaining six are positive. None of these fourteen estimated treatment effects are statistically significant.

Finally, Table 8 provides an alternative placebo test. For this placebo test, we take all mortgages chosen with the propensity score match that are similar to mortgages in shale areas. We randomly assign half of these non-treated loans a placebo treatment, and keep the other half as the control group for this placebo test. These results provide further evidence that our main findings are not spurious; out of the 14 regressions, four are statistically significant and with two of the statistically significant treatment effects as positive and two as negative. In total, nine of these placebo treatment effects are positive with the other five negative. In sum, Tables 7 and 8 provide 28 placebo treatment effects for default and mild default over each shale play separately as well as for the aggregated sample. In total, 13 of these are negative and the other 15 as positive.

Table 9 shows a comparison of the estimated treatment effects across all plays using alternative control groups. Using the propensity score matched control group, the estimated treatment effect on mortgage default and mild default, is 6.1% and 5.6% respectively. Both of these estimates are actually conservative relative to the estimated treatment effects simply using the randomly selected control groups. For default, these estimates range from 7.9% to 9.1%, compared to the propensity score match control group specification providing an estimated treatment effect of 6.1%. This pattern is consistently observed across shale plays, with the exception of Niobrara which has very similar average treatment effects using the propensity score match control group and the random control groups.

For all specifications up to this point, we have simplistically set the treatment time period starting in 2007 and extending until the end of 2014, the most recent date currently available in the data. But more realistically, the shale boom could have started, peaked, and declined in different shale plays at different points. Therefore, next we assess the timing of these effects.

Tables 10 and 11 show the marginal effects associated with the coefficients δ_{2003}, δ_{2004} $\ldots \delta_{2014}$ estimated using equation 3 for both default and mild default. From 2003 to 2006, the shale areas have a slightly lower default rate after controlling for covariates between about 1% and 2%. But starting in 2007, the default rate in the shale areas begins to decline and reaches its peak in 2009, when the shale areas has a default rate almost 9% lower than the control area, implying a treatment effect of about 7% to 8% at the boom's peak (subtracting out the pre-boom difference between the groups). The default rates steadily begin to converge once again from 2010 to 2014. By 2014, the shale areas have less than a 4% difference in default rates, down from the 9% difference observed at the peak of the book in 2009. A similar pattern is observed for mild default. These coefficient estimates and p=.95 confidence intervals are illustrated in Figure 4.

These results vary by geographic area. For example, in Table 10, Haynesville, Marcellus, and Utica all reached a peak in the magnitude of their respective treatment effects in 2009, and as of the end of sample period in 2014 the treatment effect is no longer statistically significant in any of these these plays. On the other hand, Bakken, Eagle Ford and Niabrara still have large negative statistically significant treatment effects through 2014. This not surprising, given that Haynesville, Marcellus, and Utica are primarily gas plays and gas prices began to fall in 2010, whereas Bakken, Eagle Ford, and Niabrara are primarily oil plays and oil prices did not begin to decline until mid-2015, after the end of our sample period.

5 Conclusion

The technological innovations that enabled shale oil and gas extraction provides a natural experiment that can be used to test the impact of a local labor market boom on a number of outcomes of interest. We examine the impact of this boom on mortgage payment activity on households who resided in these local areas before the shale production began. We find that the shale oil and gas boom lead to, on average, a 6% reduction on the probability of default. While point estimates vary, we estimate reductions in mortgage default in six different shale areas relative to plausible control groups.

These results are largest for near prime and prime borrowers and relatively lower for sub-prime and super-prime borrowers. These effects are also largest for borrowers with more than 80 percent loan to value rations at origination.

The divergence in mortgage default rates begins in 2007, peaking in 2009, and coming back near convergence by 2014. Thus, there is a clear pattern showing the booms beginning, peak, and approaching the end that likely ended in mid-2015 with the significant drop in global oil prices.[21]

The implications of this research are multifaceted. First, economists are in general interested in how transitory shocks can impact savings behavior, which can have long term implications. We have shown that a labor market shock can impact mortgage default for households who purchased their home in the pre-shock period. While we only identify an example of how a positive labor market shock can decrease default, it is also plausible that a negative labor market shock can have a negative impact on mortgage payment behavior.

Results of this research can have long term implications for not only households that go into default, but also for society at large. The recent financial crisis is a somber reminder of this reality. It is important for policy makers to be able to (a) be aware of how these labor market shocks impact households' mortgage payment activity, (b) have a reasonable idea of the magnitude of these shocks (c) identify the type of borrowers that are most susceptible to these shocks. This paper provides a causal estimate of local labor market shocks on mortgage payment activity, and is unique in that we examine not just one labor market boom in one area, but instead six different booms in six different parts of the country that had different timings and magnitudes of these shocks. In addition, we identify the types of borrowers with varying sensitivities to these shocks.

There is still substantial room for future research in this area. While we identify a decrease in mortgage default associated with a plausibly exogenous labor market shock, we do not explore the specific channel that impacts mortgage default. It could be that workers with higher wages are less likely to miss a mortgage payment. It could also be that households located in these areas before the boom begins do not necessarily see increases in wages, but instead if they do find themselves in a situation where they have to miss mortgage payments, they can quickly sell the property for a gain instead of going into default. Thirdly, it could be that these booms cause decreases in the time it takes for job search. Thus, a homeowner who loses a job might be able to find a job more quickly, thus reducing mortgage default. Teasing out these effects would require specific information on individual households in these areas in addition to the individual mortgage payment activity used in this study, and therefore is beyond the scope of this study.

In addition, it is currently unknown what will happen to default rates in these areas now that the boom has subsided. For instance, potentially individuals who received large

[21] Our analysis only extends through the end of 2014.

pay increases might have purchased homes that, in the long run, they cannot afford. Now that the boom has ended, these households might be particularly susceptible to default, and potentially foreclosure. With the recent drop in oil prices, this topic can be explored over the next several years.

Finally, this paper looks at aggregate effects of a "boom town" on mortgage default. But there is still ample room for investigating how specific individuals in these towns have been impacted. For instance, is the decrease in default coming from households that get jobs in the lucrative oil and gas industry? Or is it that wages in general rise due to a labor demand shock and this reduces default for households across all industries?

Understanding how economic conditions impact mortgage default has substantial implications for the U.S. and global economy. For this reason, research in this vein can augment policy makers' understanding of how much of mortgage default behavior is attributable to changes in labor market conditions or more broadly, the extent to which household financial decisions are impacted by changes in economic conditions.

6 Tables and Figures

Figure 1: Historical U.S. Crude Production

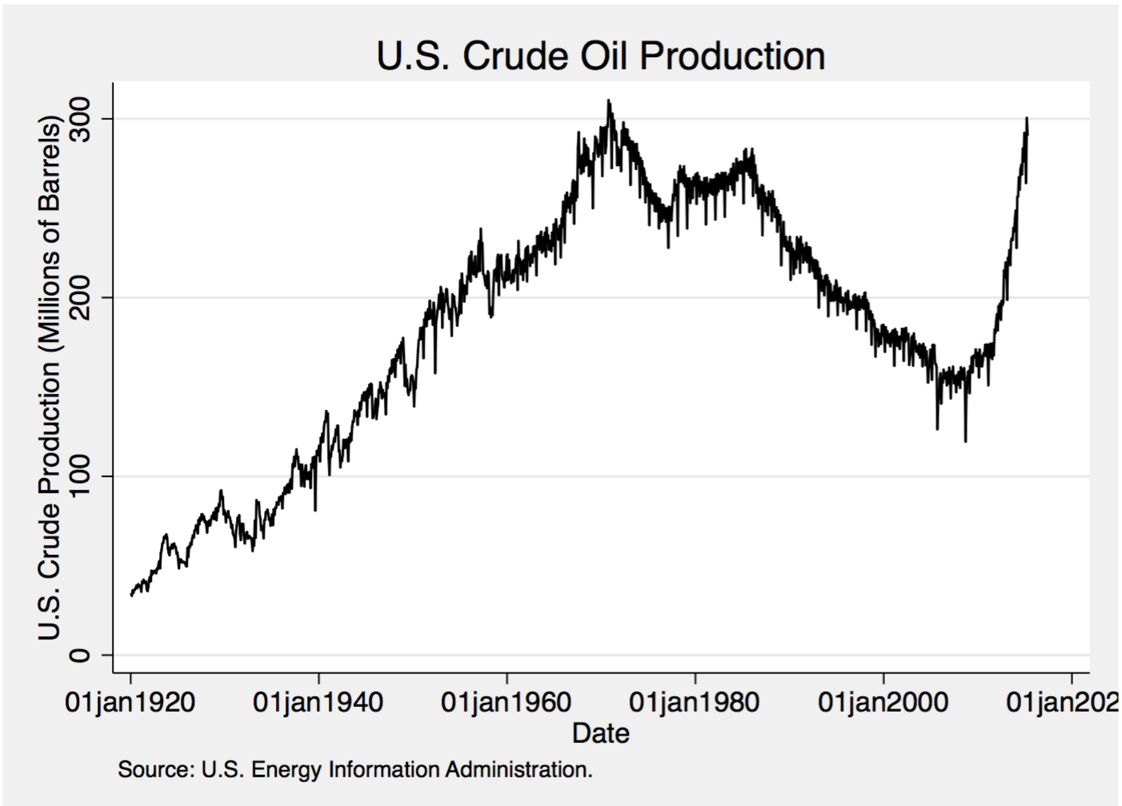


Figure 2: U.S. Shale Plays

Figure 3: Comparison of Shale and Non-Shale Areas Mortgage Default and Mild Default

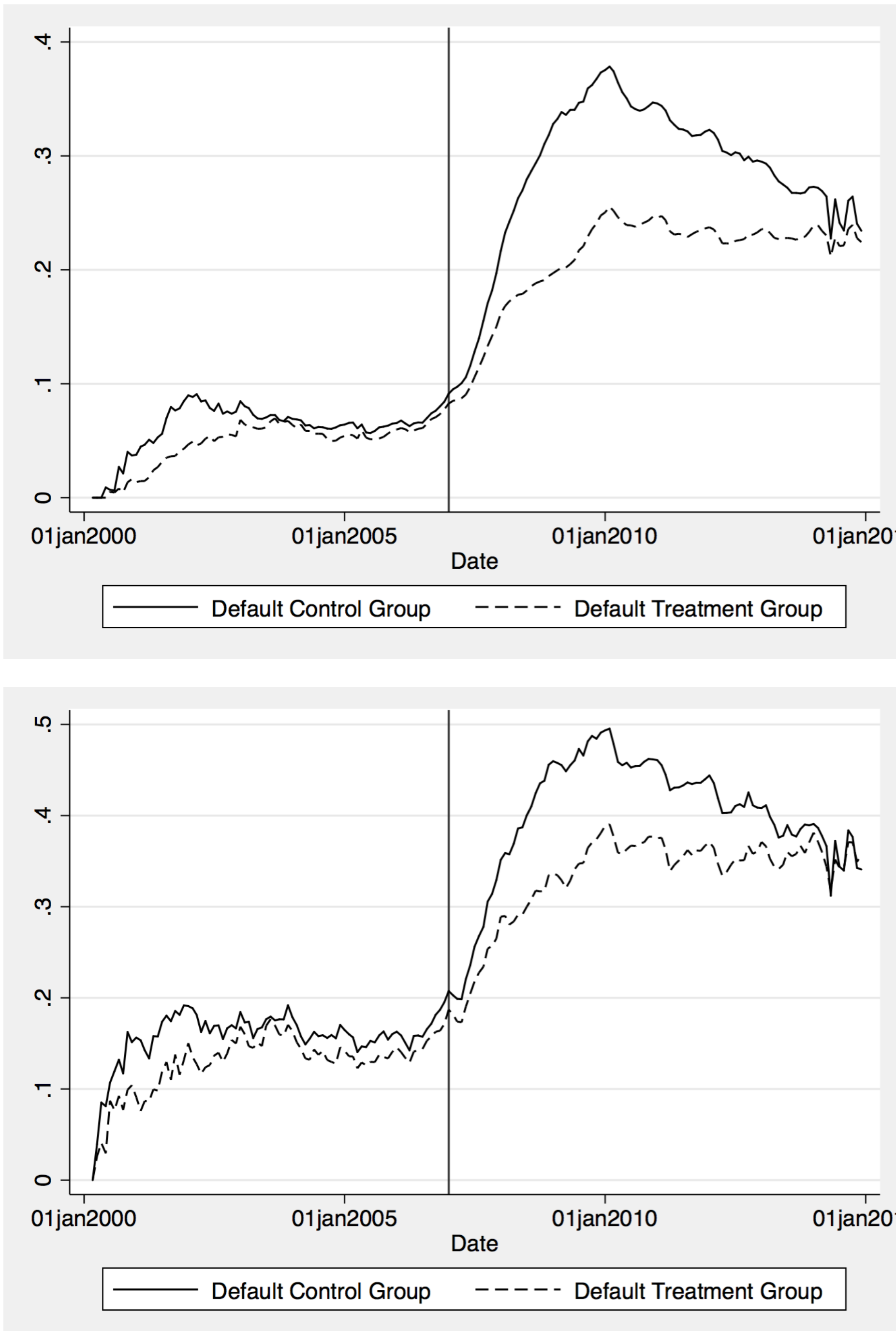
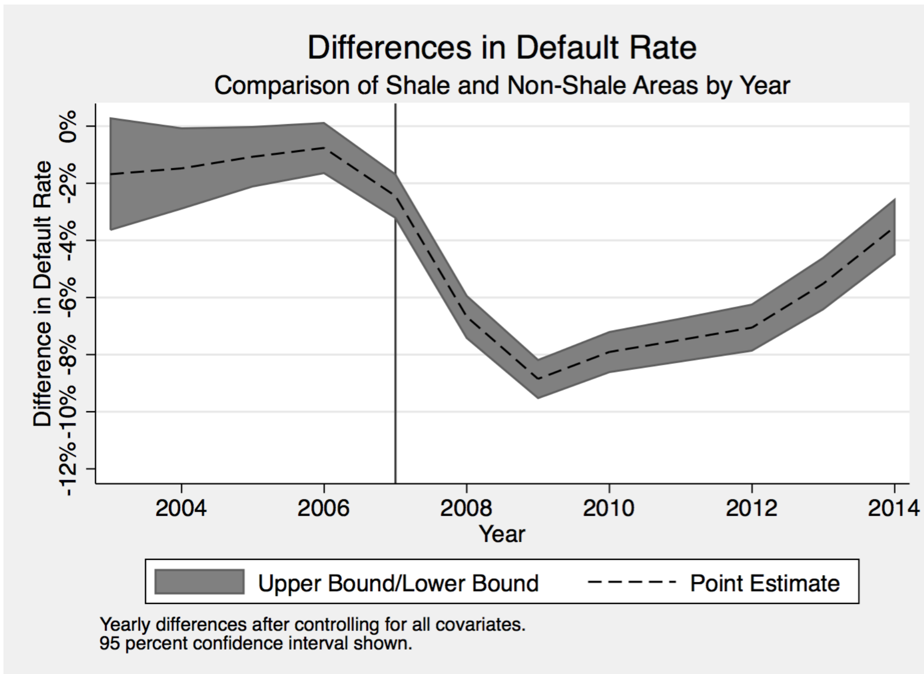


Figure 4: Comparison of Average Difference in Default Rates of Mortgages in Shale and Non-Shale Areas by Year



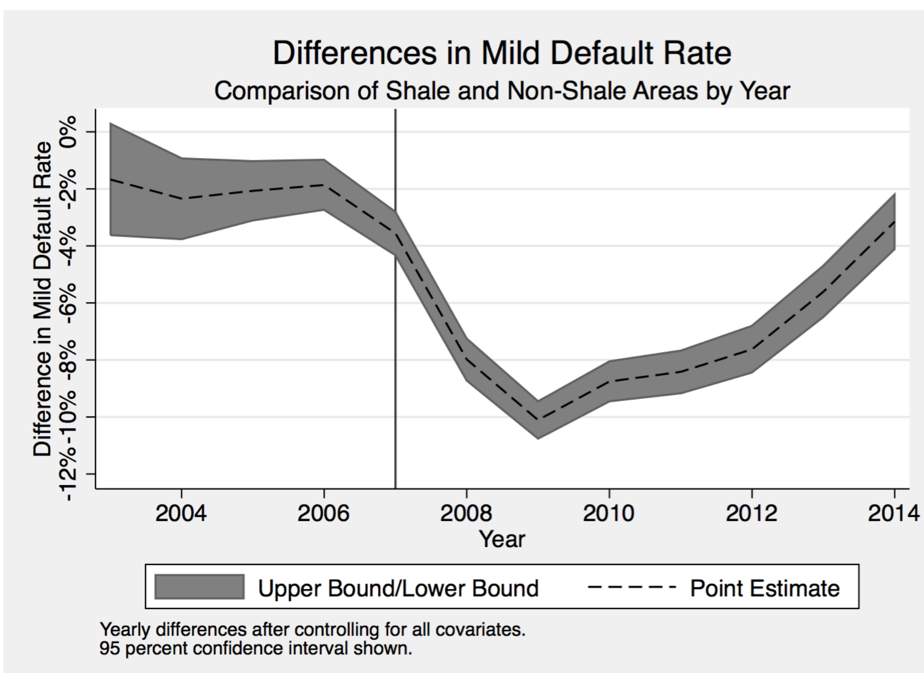


Table 1: Summary Statistics: Baseline Sample

	All			Bakken			Eagle Ford			Haynesville		
	Sample Average	Std. Dev.	N	Sample Average	Std. Dev.	N	Sample Average	Std. Dev.	N	Sample Average	Std. Dev.	N
Origination Characteristics												
FICO Score												
Treated	650.1	71.0	31,954	636.5	60.8	147	632.4	66.8	1,901	629.4	63.3	1,171
PMatch Control	649.2	68.0	31,954	644.4	69.9	147	630.7	63.3	1,901	632.3	61.4	1,171
Loan-to-Value Ratio (LTV) at Origination												
Treated	85.6%	10.7%	31,939	86.3%	10.8%	147	85.2%	8.9%	1,900	86.9%	10.3%	1,171
PMatch Control	85.2%	10.7%	31,905	86.1%	10.5%	147	85.9%	11.3%	1,898	86.0%	10.6%	1,171
Adjustable Rate Mortgage (ARM)												
Treated	45.8%	49.8%	31,954	47.6%	50.1%	147	32.7%	46.9%	1,901	42.1%	49.4%	1,171
PMatch Control	44.3%	49.7%	31,954	38.8%	.48.9%	147	31.6%	46.5%	1,901	41.5%	49.3%	1,171
30 Year Mortgage												
Treated	96.2%	19.2%	31,954	95.9%	19.9%	147	95.4%	21.0%	1,901	96.5%	18.4%	1,171
PMatch Control	96.8%	17.6%	31,954	97.3%	16.3%	147	96.9%	17.2%	1,901	98.0%	14.2%	1,171
County Level Employment												
Treated	221,155	248,403	31,954	$2,279	$203	147	70,666	35,536	1,901	107,703	53,379	1,171
PMatch Control	207,792	396,429	31,954	17,749	13,906	147	46,040	71,119	1,901	81,286	73,588	1,171
County Level Average Earnings												
Treated	$2,871	$442	31,954	$2,279	$203	147	$2,275	$175	1,901	$2,547	$170	1,171
PMatch Control	$2,849	$600	31,954	$2,288	$233	147	$2,279	$199	1,901	$2569	$238	1,171
Time Variant Characteristics												
Default												
Treated	16.3%	36.9%	1,681,336	6.1%	23.8%	6,544	12.6%	33.2%	122,590	24.0%	42.7%	68,657
PMatch Control	20.3%	40.2%	1,477,978	16.2%	36.9%	7,511	20.3%	40.2%	95,699	22.0%	41.4%	54,126
Mild Default												
Treated	27.7%	44.7%	1,681,336	20.2%	40.1%	6,544	27.8%	44.8%	122,590	37.9%	48.5%	68,657
PMatch Control	31.4%	46.4%	1,477,978	28.1%	45.0%	7,511	32.4%	46.8%	95,699	34.9%	47.7%	54,126
Interest Rate												
Treated	7.5%	1.86%	1,681,336	8.4%	1.8%	6,544	7.81%	1.70%	122,590	7.93%	1.81%	68,657
PMatch Control	7.43%	1.96%	1,477,978	8.1%	1.8%	7,511	7.80%	1.97%	95,699	7.66%	1.81%	54,126

	Marcellus			Niobrara			Utica		
	Sample Average	Std. Dev.	N	Sample Average	Std. Dev.	N	Sample Average	Std. Dev.	N
Origination Characteristics									
FICO Score									
Treated	641.9	71.4	13,832	674.0	66.8	10,733	630.0	67.3	4,170
PMatch Control	641.6	65.7	13,832	671.3	68.1	10,733	631.0	64.3	4,170
Loan-to-Value Ratio (LTV) at Origination									
Treated	87.3%	11.0%	13,828	82.1%	10.1%	10,728	88.3%	10.0%	4,165
PMatch Control	86.5%	10.5%	13,828	82.7	10.5%	10,719	86.7%	10.2%	4,165
Adjustable Rate Mortgage (ARM)									
Treated	41.2%	49.3%	13,832	53.0%	49.9%	10,733	49.3%	50.0%	4,170
PMatch Control	39.5%	48.9%	13,832	52.1%	49.9%	10,733	47.1%	50.0%	4,170
30 Year Mortgage									
Treated	95.7%	20.3%	13,832	96.8%	17.7%	10,733	96.5%	18.5%	4,170
PMatch Control	97.1%	16.8%	13,832	96.2%	19.1%	10,733	97.0%	17.1%	4,170
County Level Employment									
Treated	325,846	332,220	13,382	171,223	109,558	10,733	109,849	63,185	4,170
PMatch Control	299,363	571,445	13,382	159,840	128,338	10,733	97,458	107,645	4,170
County Level Earnings									
Treated	$2,799	$353	13,382	$3,192	$440	10,733	$2,665	$188	4,170
PMatch Control	$2,792	$438	13,382	$3,138	$768	10,733	$2,656	$360	4,170
Time Variant Characteristics									
Default									
Treated	17.2%	37.7%	781,628	11.7%	32.2%	486,224	23.2%	42.2%	215,693
PMatch Control	21.4%	41.0%	644,221	18.0%	38.5%	482,896	21.9%	41.3%	193,525
Mild Default									
Treated	29.5%	45.6%	781,628	20.0%	40.0%	486,224	35.2%	47.8%	215,693
PMatch Control	33.5%	47.2%	644,221	26.7%	44.3%	482,896	34.6%	47.6%	193,525
Interest Rate									
Treated	7.86%	1.90%	781,628	6.61%	1.49%	486,224	8.01%	1.83%	215,693
PMatch Control	7.72%	1.89%	644,221	6.73%	1.90%	482,896	7.91%	1.86%	193,525

Table 2: Cohort Analysis - Comparison of Probability of Mortgage Default in Shale and non-Shale Counties

	(1) 2007	(2) 2008	(3) 2009	(4) 2010	(5) 2011	(6) 2012	(7) 2013
Default: 90+ Days Delinquent							
2005 Cohort	-0.0192***	-0.0408***	-0.0534***	-0.0584***	-0.0614***	-0.0617***	-0.0616***
	(0.00424)	(0.00504)	(0.00539)	(0.00555)	(0.00563)	(0.00568)	(0.00572)
Observations	24,686	24,686	24,686	24,686	24,686	24,686	24,686
2006 Cohort	-0.0310***	-0.0667***	-0.0871***	-0.0868***	-0.0842***	-0.0805***	-0.0801***
	(0.00360)	(0.00464)	(0.00511)	(0.00528)	(0.00537)	(0.00543)	(0.00546)
Observations	28,453	28,453	28,453	28,453	28,453	28,453	28,453
Mild Default: 30+ Days Delinquent							
2005 Cohort	-0.0174***	-0.0376***	-0.0471***	-0.0510***	-0.0548***	-0.0532***	-0.0515***
	(0.00542)	(0.00604)	(0.00622)	(0.00628)	(0.00630)	(0.00631)	(0.00632)
Observations	24,686	24,686	24,686	24,686	24,686	24,686	24,686
2006 Cohort	-0.0322***	-0.0700***	-0.0824***	-0.0759***	-0.0702***	-0.0652***	-0.0615***
	(0.00486)	(0.00561)	(0.00580)	(0.00584)	(0.00585)	(0.00585)	(0.00584)
Observations	28,453	28,453	28,453	28,453	28,453	28,453	28,453

Mortgage default is defined as 90 days behind on mortgage payments. Mild default is defined as 30 days behind on mortgage payments.

Table 3: Impact of Shale on Mortgage Default

	(1) All	(2) Bakken	(3) Eagle Ford	(4) Haynesville	(5) Marcellus	(6) Niabrara	(7) Utica
Default: 90+ Days Delinquent							
Treatment Effect	-0.0610***	-0.0908**	-0.0410**	-0.0594**	-0.0557***	-0.0655***	-0.0617***
	(0.00557)	(0.0444)	(0.0201)	(0.0239)	(0.00765)	(0.00848)	(0.0142)
Shale Area	0.00297	-0.0809*	-0.0436**	0.0352*	-0.0109	0.00762	0.0519***
	(0.00515)	(0.0423)	(0.0190)	(0.0213)	(0.00679)	(0.00961)	(0.0128)
FICO Score	-0.0882***	-0.0658***	-0.0934***	-0.107***	-0.0869***	-0.0780***	-0.101***
	(0.00209)	(0.0240)	(0.00846)	(0.0111)	(0.00304)	(0.00339)	(0.00607)
Interest Rate	0.0217***	0.00264	0.0133***	0.0248***	0.0217***	0.0213***	0.0266***
	(0.000649)	(0.00651)	(0.00193)	(0.00289)	(0.000955)	(0.00118)	(0.00165)
LTV at Origination	0.0282**	0.104	0.0980***	0.0805	-0.00925	0.0817***	-0.0511
	(0.0122)	(0.165)	(0.0367)	(0.0628)	(0.0182)	(0.0201)	(0.0396)
Adjustable Rate Mortgage	0.0673***	0.0286	0.0489***	0.0841***	0.0670***	0.0565***	0.0927***
	(0.00329)	(0.0408)	(0.0143)	(0.0126)	(0.00467)	(0.00563)	(0.00921)
30 Year Mortgage	0.0269***	-0.0282	0.0811***	0.144***	0.0316***	-0.00244	0.00908
	(0.00814)	(0.0871)	(0.0269)	(0.0557)	(0.0120)	(0.0115)	(0.0230)
Observations	3,152,559	13,811	217,809	122,529	1,422,701	967,114	408,256
	(1) All	(2) Bakken	(3) Eagle Ford	(4) Haynesville	(5) Marcellus	(6) Niabrara	(7) Utica
Mild Default: 30+ Days Delinquent							
Treatment Effect	-0.0570***	-0.0930*	-0.0544***	-0.0503**	-0.0436***	-0.0783***	-0.0485***
	(0.00531)	(0.0476)	(0.0161)	(0.0226)	(0.00733)	(0.00776)	(0.0144)
Shale Area	-0.00605	-0.0796*	-0.0149	0.0218	-0.0291***	0.0133	0.0301**
	(0.00468)	(0.0440)	(0.0169)	(0.0178)	(0.00615)	(0.00930)	(0.0117)
FICO Score	-0.161***	-0.142***	-0.175***	-0.187***	-0.163***	-0.142***	-0.173***
	(0.00226)	(0.0340)	(0.00853)	(0.0119)	(0.00338)	(0.00365)	(0.00632)
Interest Rate	0.0231***	0.00408	0.0150***	0.0226***	0.0226***	0.0249***	0.0260***
	(0.000743)	(0.00872)	(0.00243)	(0.00290)	(0.00111)	(0.00141)	(0.00172)
LTV at Origination	0.0789***	0.236	0.141***	0.158**	0.0363	0.129***	0.0141
	(0.0147)	(0.208)	(0.0484)	(0.0679)	(0.0223)	(0.0242)	(0.0462)
Adjustable Rate Mortgage	0.0589***	0.0456	0.0351*	0.0619***	0.0598***	0.0555***	0.0848***
	(0.00386)	(0.0512)	(0.0191)	(0.0134)	(0.00551)	(0.00651)	(0.0100)
30 Year Mortgage	0.0399***	-0.0697	0.0862***	0.176***	0.0491***	-0.000657	0.0299
	(0.00871)	(0.0796)	(0.0287)	(0.0541)	(0.0128)	(0.0126)	(0.0261)
Observations	3,152,559	14,045	217,847	122,596	1422,701	967,114	408,256

Mortgage default is defined as 90 days behind on mortgage payments. Mild default is defined as 30 days behind on mortgage payments. Zip code level clustered standard errors shown. Yearly, monthly, origination year, and loan servicer fixed effects estimated in all regressions, but output not shown in table. All mortgages originated pre-shale (2001 to 2006). Treatment time period post 2007. Treated areas include mortgages in areas in counties with shale production. Control mortgages chosen using propensity score match from national sample in non-shale states. Parameters estimated with logistic regression. Marginal effects shown in table.

Table 4: Estimated Treatment Effects by Loan Risk Level

	Treatment Effect	Standard Error	N
Credit Score			
<620	-3.74%***	.009	1,163,889
621 to 680	-8.38%***	0.010	908,976
681 to 739	-9.33%***	0.012	650,395
>= 740	-4.01%***	.0122	416,586
Loan-to-Value Ratio			
>95%	-3.95%***	0.009	844,632
90.01% to 95%	-3.58%**	0.012	318,861
85.01% to 90%	-3.56%**	0.011	349,278
80.01% to 85%	-4.93%**	0.012	147,591
<=80%	-8.27%***	0.008	1,773,395

Treatment group pooled from all shale areas. Control group comes from propensity match control loans for which loans fall in same category of risk.

Table 5: Estimated Treatment for 20 Random Control Groups: Default

Iteration	All	Bakken	Eagle Ford	Haynesville	Marcellus	Niabrara	Utica
1	-.085***	-.135***	-.093***	-.055***	-.093***	-.061***	-.108***
2	-.085***	-.161***	-.010***	-.095***	-.093***	-.058***	-.107***
3	-.087***	-.179***	-.106***	-.059***	-.098***	-.062***	-.094***
4	-.091***	-.156***	-.109***	-.080***	-.097***	-.067***	-.111***
5	-.085***	-.123**	-.076***	-.114***	-.095***	-.060***	-.104***
6	-.084***	-.155***	-.085***	-.069***	-.096***	-.062***	-.088***
7	-.083***	-.180***	-.088***	-.082***	-.093***	-.058***	-.095***
8	-.084***	-.137***	-.010***	-.084***	-.090***	-.061***	-.102***
9	-.085***	-.169***	-.098***	-.071***	-.090***	-.065***	-.096***
10	-.084***	-.056	-.076***	-.081***	-.091***	-.064***	-.104***
11	-.080***	-.187***	-.102***	-.065***	-.091***	-.051***	-.101***
12	-.086***	-.141***	-.090***	-.085***	-.096***	-.061***	-.095***
13	-.087***	-.128***	-.084***	-.077***	-.096***	-.065***	-.101***
14	-.089***	-.143***	-.087***	-.089***	-.010***	-.063***	-.110***
15	-.079***	-.117**	-.096***	-.048**	-.088***	-.059***	-.087***
16	-.085***	-.161***	-.089***	-.077***	-.096***	-.062***	-.090***
17	-.086***	-.191***	-.080***	-.096***	-.092***	-.066***	-.097***
18	-.083***	-.076*	-.105***	-.061***	-.091***	-.060***	-.104***
19	-.086***	-.182***	-.082***	-.060***	-.096***	-.062***	-.108***
20	-.089***	-.199***	-.094***	-.082***	-.095***	-.068***	-.099***
Mean	-.085	-.149	-.092	-.076	-.094	-.062	-.100
Std. Dev.	.003	-.037	.010	.016	.003	.004	.007
Min	-.079	-.056	-.076	-.048	-.088	-.051	-.087
Max	-.091	-.199	-.109	-.114	-.100	-.068	-.111

Mortgage default is defined as 90 days behind on mortgage payments. Controls show in prior results also estimated in all regressions but not shown for purposes of brevity. Statistical significance based on zip code level clustered standard errors. Yearly, monthly, origination year, and loan servicer fixed effects estimated in all regressions, but output not shown in table. All mortgages originated pre-shale (2001 to 2006). Treatment time period post 2007. Treated areas include mortgages in areas in counties with shale production. Control mortgages are randomly chosen out of entire population of loans in the US; 20 random control groups are pulled for each regression run. Control group size chosen to match the number of treated loans in each regression. Parameters estimated with logistic regression. Marginal effects shown in table. Minimum and maximums in absolute values.

Table 6: Estimated Treatment for 20 Random Control Groups: Mild Default

Iteration	All	Bakken	Eagle Ford	Haynesville	Marcellus	Niabrara	Utica
1	-.078***	-.129***	-.110***	-.063***	-.080***	-.065***	-.089***
2	-.077***	-.152***	-.119***	-.095***	-.076***	-.063***	-.084***
3	-.079***	-.213***	-.133***	-.054***	-.084***	-.064***	-.075***
4	-.081***	-.190***	-.123***	-.070***	-.079***	-.071***	-.082***
5	-.078***	-.133***	-.099***	-.100***	-.081***	-.064***	-.082***
6	-.076***	-.149***	-.107***	-.067***	-.081***	-.064***	-.072***
7	-.076***	-.201***	-.118***	-.080***	-.076***	-.063***	-.078***
8	-.075***	-.125***	-.119***	-.081***	-.077***	-.062***	-.078***
9	-.076***	-.181***	-.114***	-.071***	-.077***	-.067***	-.075***
10	-.076***	-.049	-.099***	-.070***	-.078***	-.067***	-.084***
11	-.076***	-.208***	-.134***	-.056***	-.079***	-.057***	-.085***
12	-.078***	-.177***	-.113***	-.096***	-.078***	-.067***	-.076***
13	-.080***	-.154***	-.107***	-.078***	-.082***	-.068***	-.086***
14	-.081***	-.151***	-.106***	-.083***	-.086***	-.064***	-.095***
15	-.072***	-.141***	-.107***	-.064***	-.072***	-.063***	-.073***
16	-.075***	-.143***	-.104***	-.067***	-.076***	-.066***	-.068***
17	-.079***	-.172***	-.102***	-.088***	-.079***	-.066***	-.087***
18	-.075***	-.076*	-.119***	-.055***	-.076***	-.065***	-.081***
19	-.077***	-.178***	-.100***	-.072***	-.077***	-.065***	-.091***
20	-.082***	-.195***	-.117***	-.072***	-.083***	-.071***	-.085***
Mean	-.077	-.156	-.113	-.074	-.079	-.065	-.081
Std. Dev.	.002	.042	.011	.013	.003	.003	.007
Min	-.072	-.049	-.099	-.054	-.072	-.057	-.068
Max	-.082	-.212	-.134	-.100	-.086	-.071	-.095

Mild default is defined as 30 days behind on mortgage payments. Controls show in prior results also estimated in all regressions but not shown for purposes of brevity. Statistical significance based on zip code level clustered standard errors. Yearly, monthly, origination year, and loan servicer fixed effects estimated in all regressions, but output not shown in table. All mortgages originated pre-shale (2001 to 2006). Treatment time period post 2007. Treated areas include mortgages in areas in counties with shale production. Control mortgages are randomly chosen out of entire population of loans in the US; 20 random control groups are pulled for each regression run. Control group size chosen to match the number of treated loans in each regression. Parameters estimated with logistic regression. Marginal effects shown in table. Minimum and maximums in absolute values.

Table 7: Placebo Test - Using Loans in Treated Areas

	(1) All	(2) Bakken	(3) Eagle Ford	(4) Haynesville	(5) Marcellus	(6) Niabrara	(7) Utica
Default: 90+ Days Delinquent							
Placebo Treatment Effect	-0.00657	0.00291	0.0132	-0.00431	-0.000860	-0.0187	-0.0191
	(0.00709)	(0.0841)	(0.0260)	(0.0362)	(0.0103)	(0.0129)	(0.0190)
Placebo Treatment Area	0.00646	0.0144	-0.0259	-0.00780	0.00709	0.0141	0.0149
	(0.00648)	(0.0768)	(0.0232)	(0.0328)	(0.00922)	(0.0119)	(0.0169)
FICO Score	-0.0813***	-0.0839**	-0.0953***	-0.106***	-0.0782***	-0.0784***	-0.0856***
	(0.00294)	(0.0386)	(0.0117)	(0.0184)	(0.00441)	(0.00455)	(0.00870)
Interest Rate	0.0232***	0.00249	0.0164***	0.0226***	0.0250***	0.0230***	0.0235***
	(0.000953)	(0.0110)	(0.00346)	(0.00433)	(0.00139)	(0.00158)	(0.00233)
LTV at Origination	0.0336*	0.462*	0.0967	0.0738	-0.0129	0.116***	-0.0448
	(0.0182)	(0.254)	(0.0631)	(0.100)	(0.0279)	(0.0300)	(0.0528)
Adjustable Rate Mortgage	0.0814***	0.00162	0.0763***	0.0863***	0.0883***	0.0709***	0.0916***
	(0.00485)	(0.0664)	(0.0188)	(0.0257)	(0.00705)	(0.00839)	(0.0133)
30 Year Mortgage	0.0342**	-0.100	0.141**	0.224***	0.0333	-0.00791	0.0239
	(0.0146)	(0.0730)	(0.0571)	(0.0732)	(0.0216)	(0.0178)	(0.0387)
Observations	1,473,462	7,268	95,387	53,957	641,797	481,267	193,086
Mild Default: 30+ Days Delinquent							
Placebo Treatment Effect	-0.000789	0.0563	0.00915	0.0465	-0.00500	0.00359	-0.0125
	(0.00675)	(0.0820)	(0.0193)	(0.0363)	(0.00926)	(0.0142)	(0.0153)
Placebo Treatment Area	0.00201	0.0166	-0.0327**	-0.00565	0.00152	0.00741	0.00825
	(0.00568)	(0.0522)	(0.0160)	(0.0376)	(0.00790)	(0.0103)	(0.0150)
FICO Score	-0.173***	-0.197***	-0.183***	-0.199***	-0.176***	-0.145***	-0.190***
	(0.00295)	(0.0244)	(0.0120)	(0.0146)	(0.00451)	(0.00509)	(0.00791)
Interest Rate	0.0212***	0.00636	0.0143***	0.0218***	0.0185***	0.0258***	0.0281***
	(0.00101)	(0.0105)	(0.00275)	(0.00344)	(0.00154)	(0.00199)	(0.00239)
LTV at Origination	0.0677***	-0.0606	0.165***	0.136	0.0301	0.106***	0.0125
	(0.0209)	(0.122)	(0.0529)	(0.103)	(0.0314)	(0.0381)	(0.0674)
Adjustable Rate Mortgage	0.00158	0.0401	0.0326***	0.0135	-0.00501	0.00871	-0.00959
	(0.00354)	(0.102)	(0.00778)	(0.0171)	(0.00483)	(0.00620)	(0.00957)
30 Year Mortgage	0.0401***	-0.117	0.0612*	0.175**	0.0506***	0.00474	0.0123
	(0.0105)	(0.0917)	(0.0359)	(0.0742)	(0.0154)	(0.0173)	(0.0319)
Observations	1,679,097	6,417	122,452	68,591	780,904	485,437	215,170

Mortgage default is defined as 90 days behind on mortgage payments. Mild default is defined as 30 days behind on mortgage payments. Zip code level clustered standard errors shown. Yearly, monthly, origination year, and loan servicer fixed effects estimated in all regressions, but output not shown in table. All mortgages originated pre-shale. Treatment time period post 2007. Half of mortgages in shale areas randomly assigned to "treatment" group; the other half of mortgages in shale areas assigned to "control" group. Parameters estimated with logistic regression. Marginal effects shown in table.

Table 8: Placebo Test: Using Loans in Control Areas

	(1) All	(2) Bakken	(3) Eagle Ford	(4) Haynesville	(5) Marcellus	(6) Niabrara	(7) Utica
Default: 90+ Days Delinquent							
Placebo Treatment Effect	0.0130**	0.0183	0.00645	0.0382	0.00593	0.0253***	0.00422
	(0.00605)	(0.0560)	(0.0165)	(0.0267)	(0.00934)	(0.00906)	(0.0185)
Placebo Treatment Area	-0.00883	0.0127	-0.00249	-0.0382*	0.000462	-0.0221***	-0.00577
	(0.00569)	(0.0291)	(0.0199)	(0.0216)	(0.00833)	(0.00777)	(0.0188)
FICO Score	-0.102***	-0.0993***	-0.0982***	-0.121***	-0.103***	-0.0828***	-0.128***
	(0.00279)	(0.0232)	(0.0125)	(0.0149)	(0.00406)	(0.00434)	(0.00782)
Interest Rate	0.0194***	0.00264	0.0113***	0.0271***	0.0182***	0.0196***	0.0284***
	(0.000881)	(0.0111)	(0.00185)	(0.00378)	(0.00131)	(0.00167)	(0.00240)
LTV at Origination	0.0154	0.00201	0.123***	0.0220	-0.00646	0.0522*	-0.0835
	(0.0163)	(0.131)	(0.0309)	(0.0925)	(0.0240)	(0.0290)	(0.0581)
Adjustable Rate Mortgage	0.00842***	0.0673	0.0316***	0.0219	0.00495	0.0141***	-0.0102
	(0.00300)	(0.0465)	(0.00583)	(0.0145)	(0.00431)	(0.00433)	(0.00850)
30 Year Mortgage	0.0318***	-0.0356	0.0448*	0.148**	0.0390***	0.00749	-0.00398
	(0.00935)	(0.0844)	(0.0237)	(0.0636)	(0.0138)	(0.0159)	(0.0278)
Observations	1,679,097	6,252	122,422	68,572	780,904	485,437	214,870
Mild Default: 30+ Days Delinquent							
Placebo Treatment Effect	-0.00165	-0.118***	-0.0427**	-0.0198	0.00472	-0.00505	0.0167
	(0.00595)	(0.0394)	(0.0186)	(0.0286)	(0.00899)	(0.00904)	(0.0182)
Placebo Treatment Area	0.00139	0.0738	0.0436***	0.0119	-0.00540	0.00343	-0.00851
	(0.00490)	(0.0464)	(0.0160)	(0.0264)	(0.00770)	(0.00709)	(0.0150)
FICO Score	-0.173***	-0.189***	-0.183***	-0.199***	-0.176***	-0.145***	-0.190***
	(0.00295)	(0.0266)	(0.0120)	(0.0148)	(0.00450)	(0.00504)	(0.00789)
Interest Rate	0.0212***	0.0101	0.0142***	0.0215***	0.0185***	0.0258***	0.0281***
	(0.00101)	(0.0101)	(0.00277)	(0.00339)	(0.00154)	(0.00200)	(0.00241)
LTV at Origination	0.0677***	0.0971	0.172***	0.137	0.0302	0.106***	0.0126
	(0.0209)	(0.108)	(0.0532)	(0.0998)	(0.0315)	(0.0380)	(0.0675)
Adjustable Rate Mortgage	0.00158	0.0487	0.0324***	0.0139	-0.00502	0.00864	-0.00975
	(0.00354)	(0.106)	(0.00797)	(0.0164)	(0.00482)	(0.00615)	(0.00949)
30 Year Mortgage	0.0401***	-0.0785	0.0584*	0.170**	0.0506***	0.00479	0.0114
	(0.0105)	(0.0865)	(0.0350)	(0.0759)	(0.0154)	(0.0170)	(0.0320)
Observations	1,679,097	6,417	122,452	68,591	780,904	485,437	215,170

Mortgage default is defined as 90 days behind on mortgage payments. Mild default is defined as 30 days behind on mortgage payments. Zip code level clustered standard errors shown. Yearly, monthly, origination year, and loan servicer fixed effects estimated in all regressions, but output not shown in table. All mortgages originated pre-shale. Treatment time period post 2007. Half of mortgages chosen using propensity match that are not in shale areas are randomly assigned to "treatment" group; the other half of mortgages in non-shale areas assigned to "control" group. Parameters estimated with logistic regression. Marginal effects shown in table.

Table 9: Comparison of Estimated Treatment Effects

	All	Bakken	Eagle Ford	Haynesville	Marcellus	Niabrara	Utica
Default							
Propensity Match Control Group	-6.1%	-9.1%	-4.1%	-5.9%	-5.6%	-6.6%	-6.2%
Random Control Group (Min)	-7.9%	-5.6%	-7.6%	-4.8%	-8.8%	-5.1%	-8.7%
Random Control Group (Mean)	-8.5%	-14.9%	-9.2%	-7.6%	-9.4%	-6.2%	-10.0%
Random Control Group (Max)	-9.1%	-19.9%	-10.9%	-11.4%	-10.0%	-6.8%	-11.1%
Mild Default							
Propensity Match Control Group	-5.7%	-9.3%	-5.4%	-5.0%	-4.4%	-7.8%	-4.9%
Random Control Group (Min)	-7.2%	-4.9%	-9.9%	-5.4%	-7.2%	-5.7%	-6.8%
Random Control Group	-7.7%	-15.6%	-11.3%	-7.4%	-7.9%	-6.5%	-8.1%
Random Control Group (Max)	-8.2%	-21.2%	-13.4%	-10.0%	-8.6%	-7.1%	-9.5%

Minimum and maximums in absolute values. All values pulled from Tables 3, 5 and 6.

Table 10: Difference in Default Rates in Shale and Non-Shale Areas By Year

	(1) All	(2) Bakken	(3) Eagle Ford	(4) Haynesville	(5) Marcellus	(6) Niabrara	(7) Utica
Treatment Effect 2003	-0.0168*	0.0251	-0.0866**	-0.0714	-0.0416***	0.0108	0.0473*
	(0.00998)	(0.0695)	(0.0375)	(0.0488)	(0.0147)	(0.0162)	(0.0263)
Treatment Effect 2004	-0.0148**	-0.0324	-0.0469	-0.0207	-0.0361***	0.0139	0.0157
	(0.00720)	(0.0607)	(0.0298)	(0.0449)	(0.0107)	(0.0125)	(0.0184)
Treatment Effect 2005	-0.0107**	-0.0821	-0.0606**	-0.0300	-0.0266***	0.0202**	0.0112
	(0.00535)	(0.0666)	(0.0239)	(0.0269)	(0.00761)	(0.00960)	(0.0134)
Treatment Effect 2006	-0.00761*	-0.169***	-0.0722***	-0.00206	-0.0320***	0.0226***	0.0280***
	(0.00448)	(0.0472)	(0.0161)	(0.0193)	(0.00645)	(0.00751)	(0.0106)
Treatment Effect 2007	-0.0245***	-0.221***	-0.0786***	0.0194	-0.0507***	-0.00326	0.0134
	(0.00387)	(0.0407)	(0.0106)	(0.0143)	(0.00511)	(0.00644)	(0.00861)
Treatment Effect 2008	-0.0668***	-0.230***	-0.0955***	0.00454	-0.0863***	-0.0585***	-0.0166**
	(0.00378)	(0.0361)	(0.0123)	(0.0135)	(0.00433)	(0.00610)	(0.00775)
Treatment Effect 2009	-0.0885***	-0.197***	-0.0986***	-0.0430***	-0.0925***	-0.0868***	-0.0520***
	(0.00338)	(0.0390)	(0.0100)	(0.0154)	(0.00465)	(0.00462)	(0.00834)
Treatment Effect 2010	-0.0791***	-0.219***	-0.0913***	-0.0306*	-0.0798***	-0.0781***	-0.0471***
	(0.00357)	(0.0408)	(0.0106)	(0.0170)	(0.00558)	(0.00445)	(0.00967)
Treatment Effect 2011	-0.0749***	-0.196***	-0.111***	-0.0169	-0.0698***	-0.0788***	-0.0371***
	(0.00381)	(0.0497)	(0.0106)	(0.0195)	(0.00570)	(0.00491)	(0.0106)
Treatment Effect 2012	-0.0705***	-0.199***	-0.120***	-0.0184	-0.0496***	-0.0941***	-0.0283**
	(0.00415)	(0.0517)	(0.0127)	(0.0190)	(0.00601)	(0.00573)	(0.0117)
Treatment Effect 2013	-0.0551***	-0.158***	-0.134***	0.0128	-0.0262***	-0.0953***	-0.00544
	(0.00460)	(0.0531)	(0.0135)	(0.0199)	(0.00624)	(0.00630)	(0.0129)
Treatment Effect 2014	-0.0353***	-0.150***	-0.106***	0.0296	-0.000527	-0.0832***	-0.00352
	(0.00487)	(0.0542)	(0.0139)	(0.0190)	(0.00663)	(0.00694)	(0.0137)
FICO Score	-0.0896***	-0.108***	-0.0928***	-0.0964***	-0.0915***	-0.0836***	-0.0993***
	(0.00163)	(0.0209)	(0.00636)	(0.00813)	(0.00254)	(0.00241)	(0.00476)
Interest Rate	0.0228***	0.00390	0.0168***	0.0238***	0.0213***	0.0257***	0.0267***
	(0.000526)	(0.00642)	(0.00161)	(0.00241)	(0.000805)	(0.000861)	(0.00134)
LTV at Origination	0.0161	0.0680	0.0293	0.00747	-0.00252	0.0649***	-0.0467
	(0.00997)	(0.140)	(0.0336)	(0.0459)	(0.0152)	(0.0163)	(0.0312)
Adjustable Rate Mortgage	0.0677***	0.0329	0.0535***	0.0910***	0.0665***	0.0571***	0.0931***
	(0.00278)	(0.0341)	(0.0138)	(0.0127)	(0.00406)	(0.00439)	(0.00780)
30 Year Mortgage	0.0191***	-0.0457	0.0109	0.0895**	0.0184*	0.00973	0.0366*
	(0.00627)	(0.0611)	(0.0229)	(0.0394)	(0.00964)	(0.00984)	(0.0196)
Observations	4818286	19704	283063	185835	1965975	1743385	620104

Mortgage default is defined as 90 days behind on mortgage payments. Zip code level clustered standard errors shown. Yearly, monthly, origination year, and loan servicer fixed effects estimated in all regressions, but output not shown in table. All mortgages originated pre-shale. Treatment time period post 2007. Treated areas include mortgages in areas in counties with shale production. Control mortgages chosen using propensity score match from national sample in non-shale states. Parameters estimated with logistic regression. Marginal effects shown in table.

Table 11: Difference in Mild Default Rates in Shale and Non-Shale Areas By Year

	(1) All	(2) Bakken	(3) Eagle Ford	(4) Haynesville	(5) Marcellus	(6) Niabrara	(7) Utica
Treatment Effect 2003	-0.0167**	-0.0386	-0.0308	-0.0707*	-0.0490***	0.0148	0.0305
	(0.00818)	(0.0745)	(0.0296)	(0.0399)	(0.0124)	(0.0134)	(0.0232)
Treatment Effect 2004	-0.0234***	-0.111*	-0.0159	-0.00960	-0.0540***	0.0202**	-0.0181
	(0.00626)	(0.0613)	(0.0265)	(0.0300)	(0.00911)	(0.0102)	(0.0165)
Treatment Effect 2005	-0.0207***	0.00267	-0.0502***	-0.0221	-0.0457***	0.0142*	-0.000199
	(0.00462)	(0.0606)	(0.0176)	(0.0204)	(0.00667)	(0.00815)	(0.0119)
Treatment Effect 2006	-0.0186***	-0.173***	-0.0532***	-0.0130	-0.0470***	0.0117*	0.0128
	(0.00411)	(0.0434)	(0.0145)	(0.0166)	(0.00579)	(0.00709)	(0.00989)
Treatment Effect 2007	-0.0356***	-0.231***	-0.0664***	0.00706	-0.0645***	-0.0119*	-0.00265
	(0.00391)	(0.0416)	(0.0128)	(0.0138)	(0.00517)	(0.00662)	(0.00874)
Treatment Effect 2008	-0.0798***	-0.249***	-0.0974***	-0.00434	-0.0936***	-0.0735***	-0.0446***
	(0.00414)	(0.0408)	(0.0135)	(0.0168)	(0.00497)	(0.00703)	(0.00876)
Treatment Effect 2009	-0.101***	-0.221***	-0.119***	-0.0483**	-0.102***	-0.103***	-0.0604***
	(0.00402)	(0.0483)	(0.0145)	(0.0203)	(0.00578)	(0.00558)	(0.0103)
Treatment Effect 2010	-0.0876***	-0.186***	-0.111***	-0.0191	-0.0850***	-0.0906***	-0.0534***
	(0.00415)	(0.0489)	(0.0157)	(0.0199)	(0.00652)	(0.00535)	(0.0116)
Treatment Effect 2011	-0.0842***	-0.129**	-0.130***	-0.0197	-0.0758***	-0.0917***	-0.0488***
	(0.00439)	(0.0649)	(0.0152)	(0.0231)	(0.00684)	(0.00586)	(0.0124)
Treatment Effect 2012	-0.0763***	-0.176***	-0.128***	-0.000408	-0.0522***	-0.107***	-0.0281**
	(0.00477)	(0.0629)	(0.0163)	(0.0235)	(0.00731)	(0.00651)	(0.0132)
Treatment Effect 2013	-0.0561***	-0.102	-0.135***	0.0368	-0.0246***	-0.0973***	-0.0102
	(0.00515)	(0.0636)	(0.0177)	(0.0239)	(0.00741)	(0.00707)	(0.0145)
Treatment Effect 2014	-0.0315***	-0.0277	-0.0931***	0.0500**	0.0128*	-0.0885***	-0.01000
	(0.00530)	(0.0689)	(0.0171)	(0.0232)	(0.00759)	(0.00778)	(0.0149)
FICO Score	-0.161***	-0.192***	-0.181***	-0.173***	-0.167***	-0.144***	-0.168***
	(0.00175)	(0.0205)	(0.00622)	(0.00943)	(0.00279)	(0.00274)	(0.00497)
Interest Rate	0.0252***	0.00620	0.0191***	0.0237***	0.0226***	0.0307***	0.0268***
	(0.000598)	(0.00809)	(0.00196)	(0.00251)	(0.000939)	(0.000972)	(0.00144)
LTV at Origination	0.0656***	0.0529	0.0693	0.0533	0.0422**	0.114***	0.00993
	(0.0117)	(0.149)	(0.0434)	(0.0507)	(0.0178)	(0.0199)	(0.0356)
Adjustable Rate Mortgage	0.0605***	0.0815*	0.0424**	0.0872***	0.0595***	0.0558***	0.0846***
	(0.00315)	(0.0443)	(0.0175)	(0.0133)	(0.00466)	(0.00503)	(0.00841)
30 Year Mortgage	0.0317***	-0.0955	0.0266	0.131***	0.0347***	0.0184*	0.0447**
	(0.00690)	(0.0785)	(0.0244)	(0.0432)	(0.0107)	(0.0107)	(0.0219)
Observations	4818286	19704	283063	186012	1965975	1743385	620104

Mortgage default is defined as 30 days behind on mortgage payments. Zip code level clustered standard errors shown. Yearly, monthly, origination year, and loan servicer fixed effects estimated in all regressions, but output not shown in table. All mortgages originated pre-shale. Treatment time period post 2007. Treated areas include mortgages in areas in counties with shale production. Control mortgages chosen using propensity score match from national sample in non-shale states. Parameters estimated with logistic regression. Marginal effects shown in table.

References

D. Acemoglu, A. Finkelstein, and M. J. Notowidigdo. Income and health spending: Evidence from oil price shocks. *The Review of Economics and Statistics*, 95(4):1079–95, 2013.

H. Allcott and D. Keniston. Dutch disease or agglomeration? the local economic effects of natural resource booms in modern america. *NBER Working Paper 20508*, 2014.

D. Black, K. Daniel, and S. Sanders. The impact of economic conditions on participation in disability programs: Evidence from the coal boom and bust. *American Economic Review*, 92(1):27–50, March 2002.

D. Black, T. McKinnish, and S. Sanders. The economic impact of the coal boom and bust. *Economic Journal*, 115(503):449–476, 2005.

P. C. Boxall, W. H. Chan, and M. L. McMillan. The impact of oil and natural gas facilities on rural residential property values: a spacial hedonic analysis. *Resource and Energy Economics*, 27:248–269, 2005.

T. S. Campbell and J. K. Dietrich. The determinants of default on insured conventional residential mortgage loans. *Journal of Finance*, 38(5):1569–81, 1983.

M. A. Davis and J. Heathcote. Housing and the business cycle. *International Economic Review*, 46(3), 2005.

Y. Demyanyk and O. V. Hemert. Understanding the subprime mortgage crisis. *The Review of Financial Studies*, pages 1848–1880, June 2011.

EIA. Total petroleum and other liquids production. Technical report, U.S. Energy Information Administration, 2014.

EIA. Drilling productivity report: For key tight oil and shale gas regions. Technical report, U.S. Energy Information Administration, 2015.

J. Feyrer, E. T. Mansur, and B. Sacerdote. Geographic dispersion of economic shocks: Evidence from the fracking revolution. *NBER Working Paper 21624*, 2015.

E. Gilje. Does local access to finance matter? evidence from u.s. oil and natural gas shale booms. *Working Paper*, 2012.

E. Gilje, E. Loutskina, and P. E. Strahan. Exporting liquidity: Branch banking and financial integration. *Journal of Finance*, Forthcoming.

S. Gopalakrishnan and H. A. Klaiber. Is the shale energy boom a bust for nearby residents? evidence from housing values in pennsylvania. *American Journal of Agricultural Economics*, 96(1):43–66, 2014.

M. Iacoviello. Housing wealth and consumption. *International Encyclopedia of Housing and Home*, 2011.

E. E. Leamer. Housing is the business cycle. *NBER Working Paper 13428*, 2008.

L. J. Mester. What's the point of credit scoring? *Business Review*, September/October 1997.

L. Muehlenbachs, E. Spiller, and C. Timmins. The housing market impacts of shale gas development. *The American Economic Review*, 105(12):3633–3659, 2015.

R. G. Quercia and M. A. Stegman. Residential mortgage default: A review of the literature. *Journal of Housing Research*, 3(2):341–379, 1992.

Y. Shen, C. Cunningham, and K. Geraldi. Unexpected wealth change and mortgage default: Evidence from the shale gas boom. *Working Paper*, 2015.

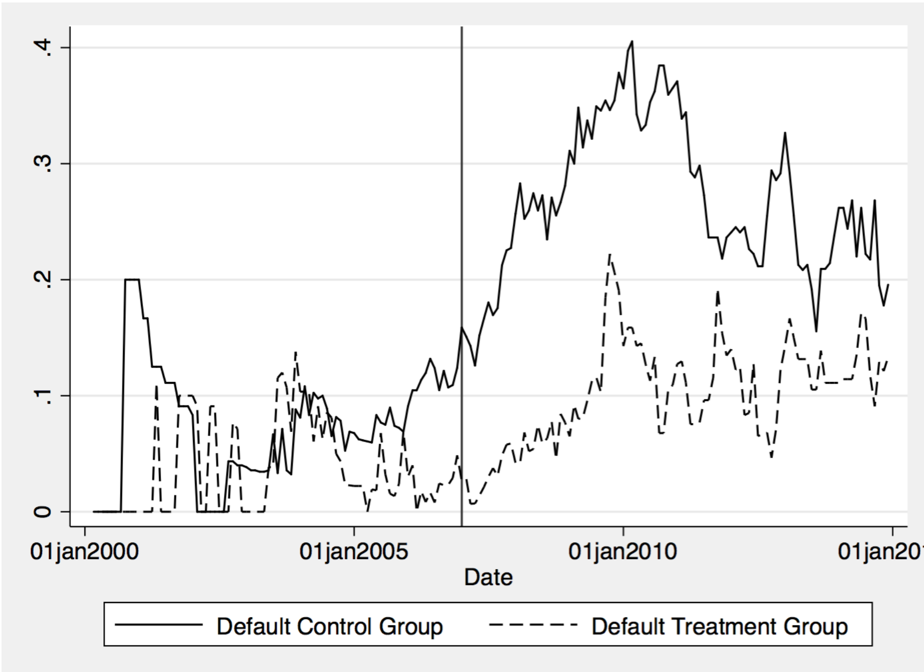
M. C. Vachon. The impact of local labor market conditions on migration: Evidence from the bakken oil boom. *Working Paper*, 2015a.

M. C. Vachon. Oil production and the elasticity of the state tax base: Evidence from north dakota. *Working Paper*, 2015b.

G. M. von Furstenberg. Default risk on fha-insured home mortgages as a function of the terms of financing: A quantitative analysis. *Journal of Finance*, 24:459–77, 1969.

D. Yergin. *The Prize. The Epic Quest for Oil, Money and Power.* Free Press, 1999.

Figure A1: Bakken: Comparison of Shale and Non-Shale Areas Mortgage Default and Mild Default



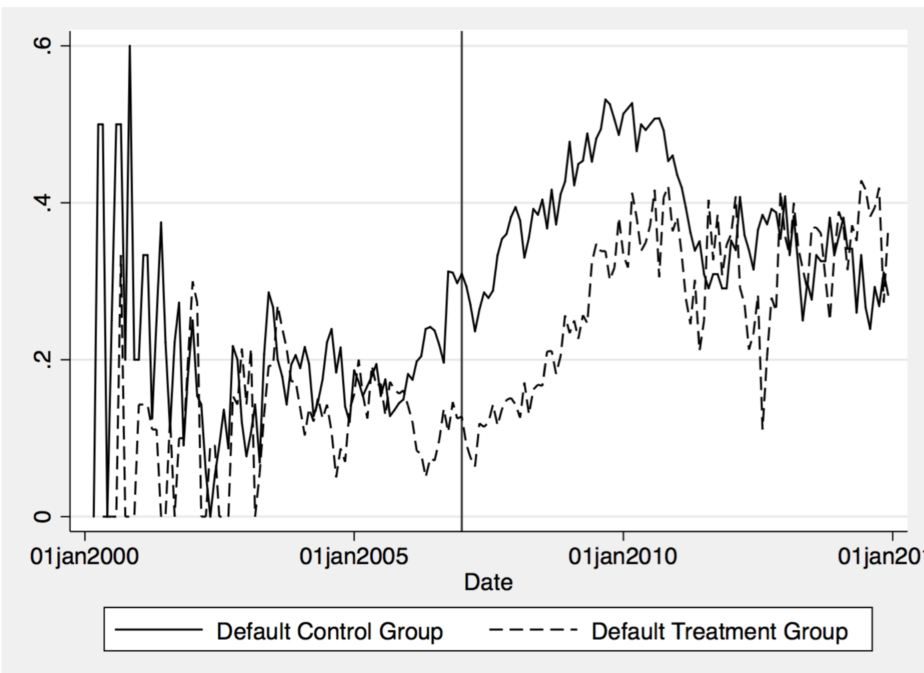


Figure A2: Eagle Ford: Comparison of Shale and Non-Shale Areas Mortgage Default and Mild Default

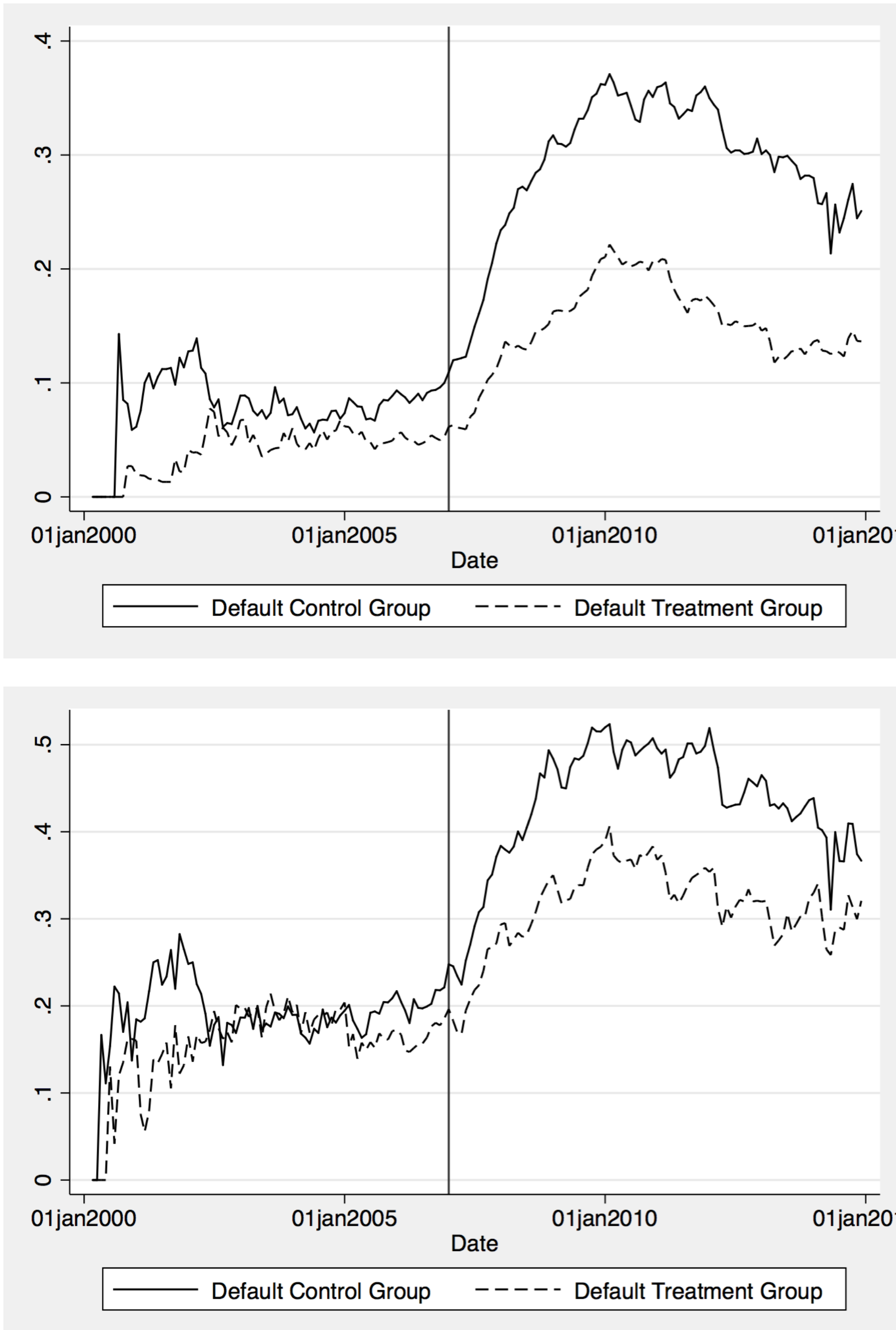
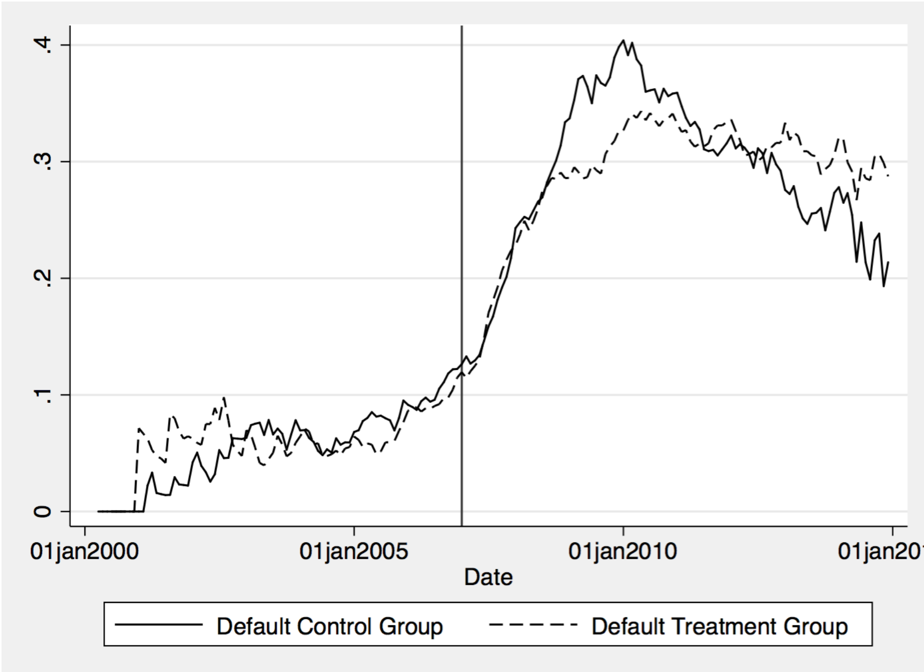


Figure A3: Haynesville: Comparison of Shale and Non-Shale Areas Mortgage Default and Mild Default



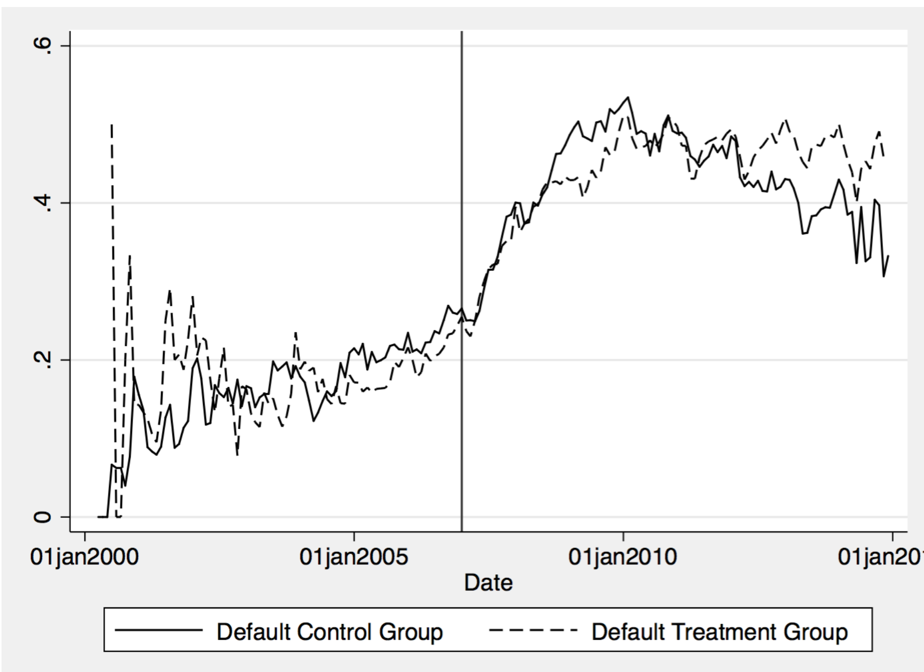
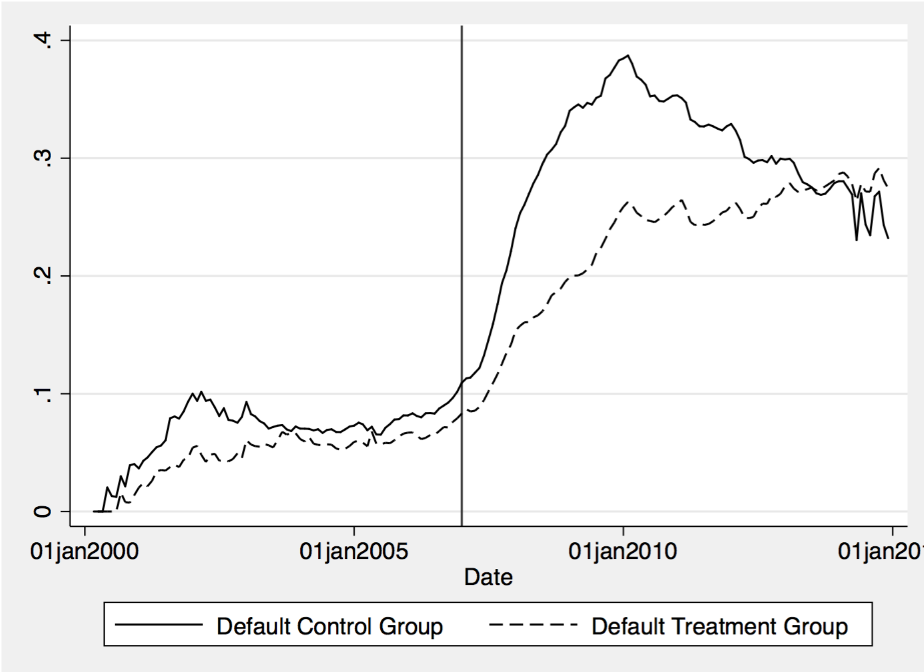


Figure A4: Marcellus: Comparison of Shale and Non-Shale Areas Mortgage Default and Mild Default



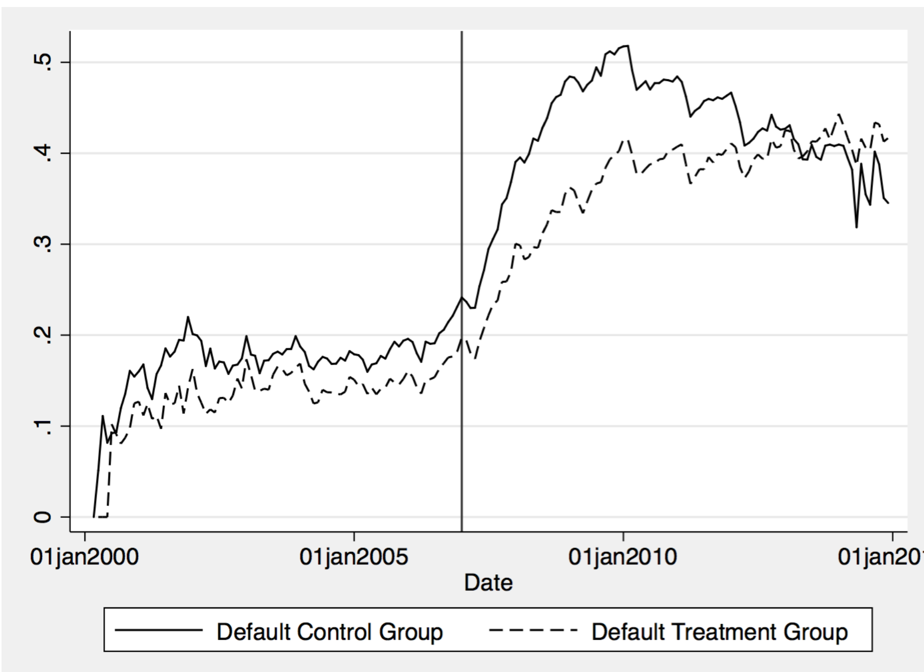
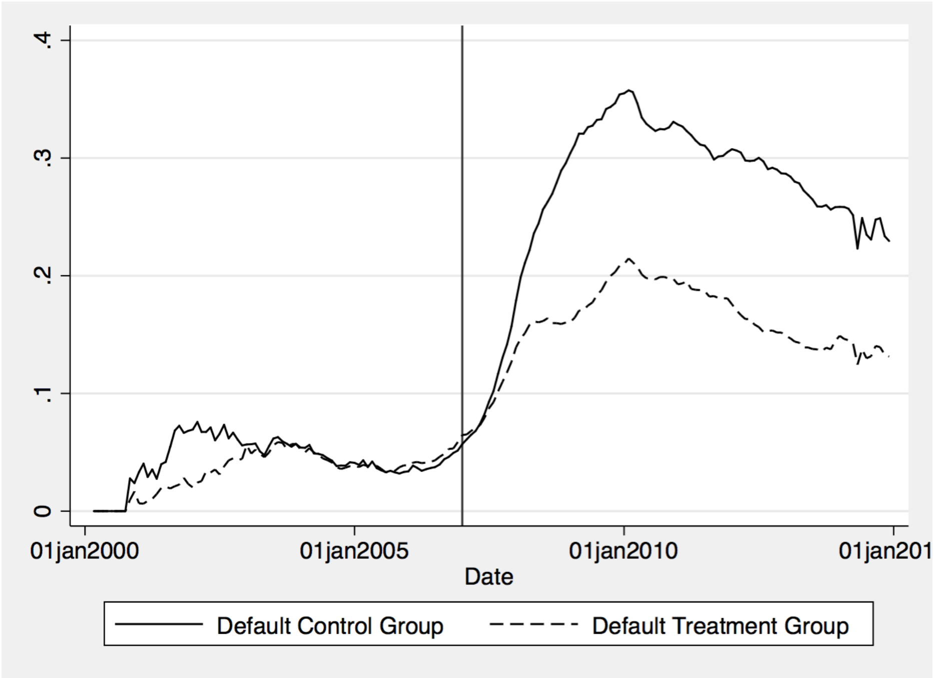


Figure A5: Niobrara: Comparison of Shale and Non-Shale Areas Mortgage Default and Mild Default



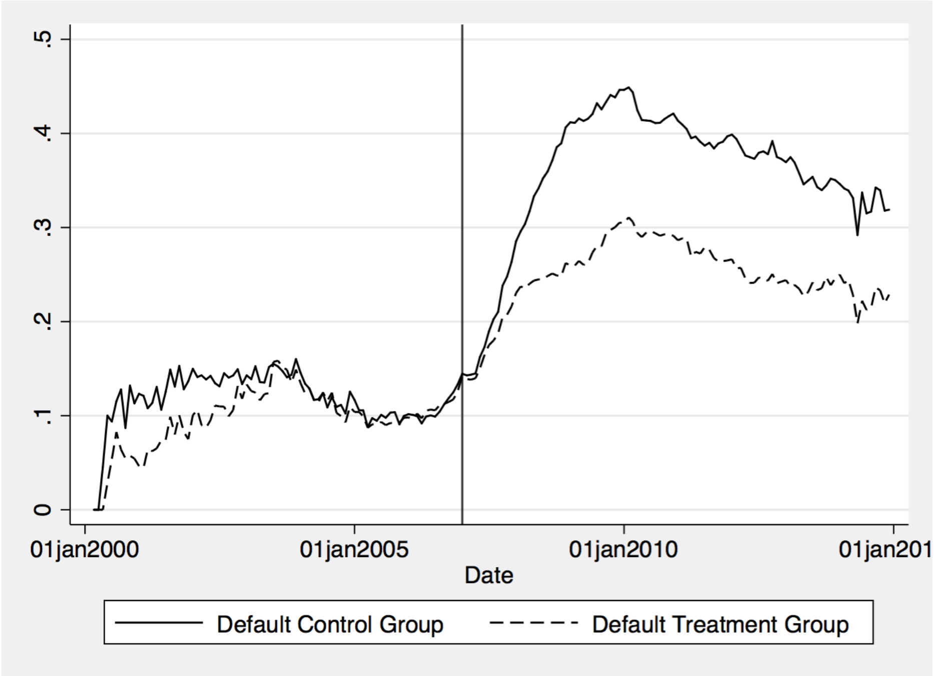
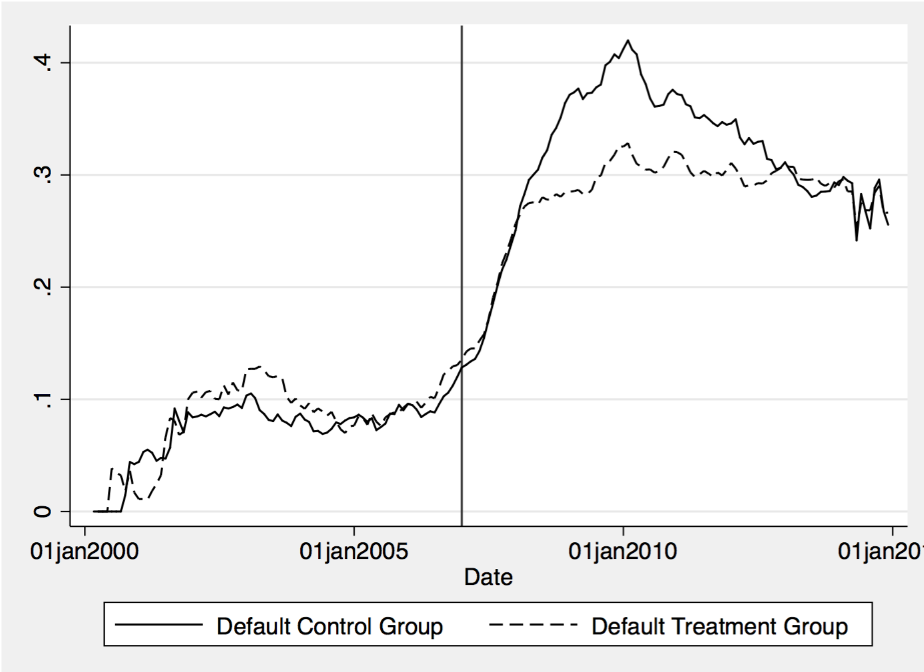


Figure A6: Utica: Comparison of Shale and Non-Shale Areas Mortgage Default and Mild Default



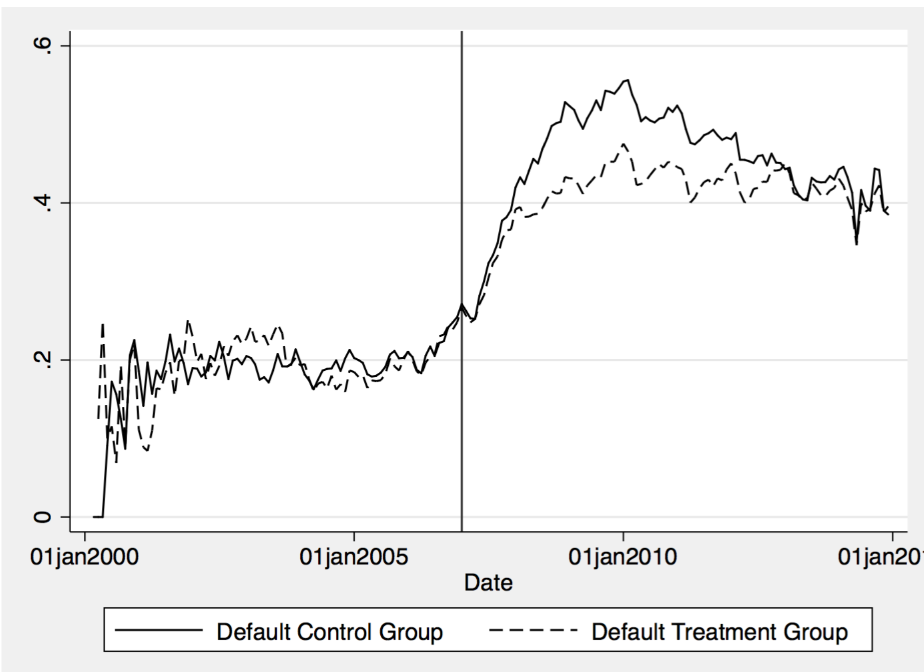
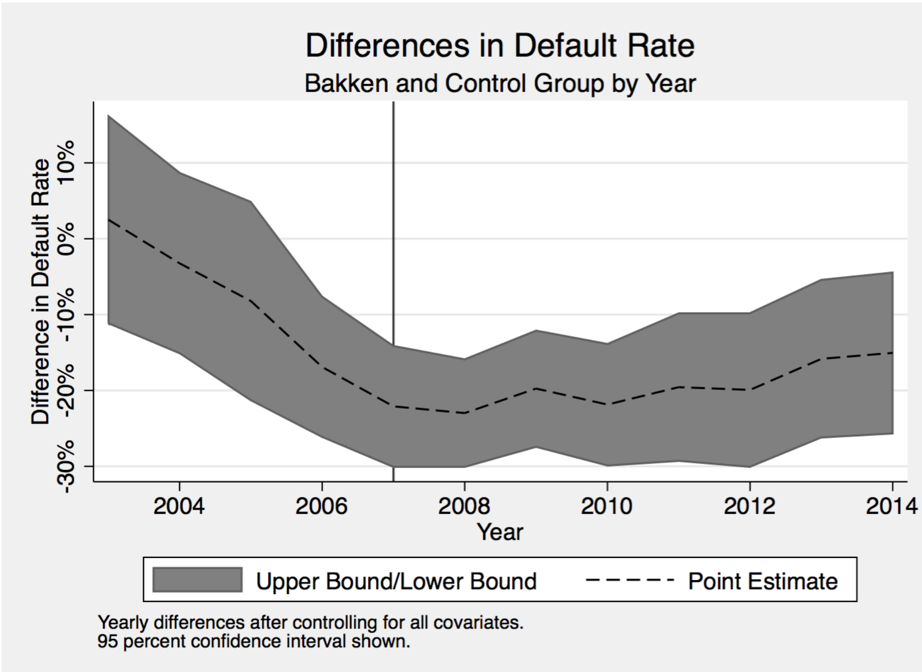


Figure A7: Bakken: Comparison of Average Difference in Default Rates of Mortgages in Shale and Non-Shale Areas by Year



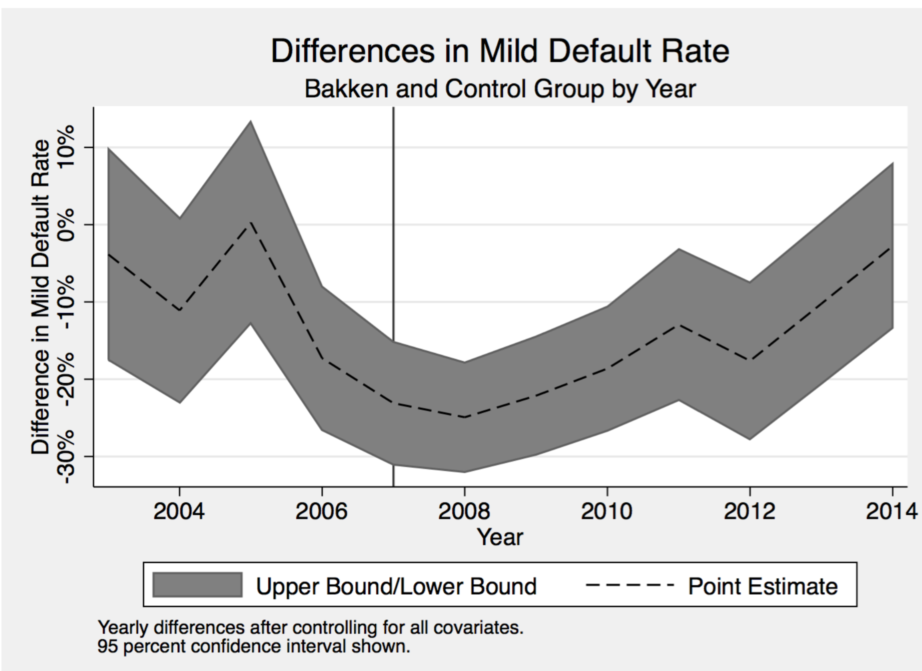
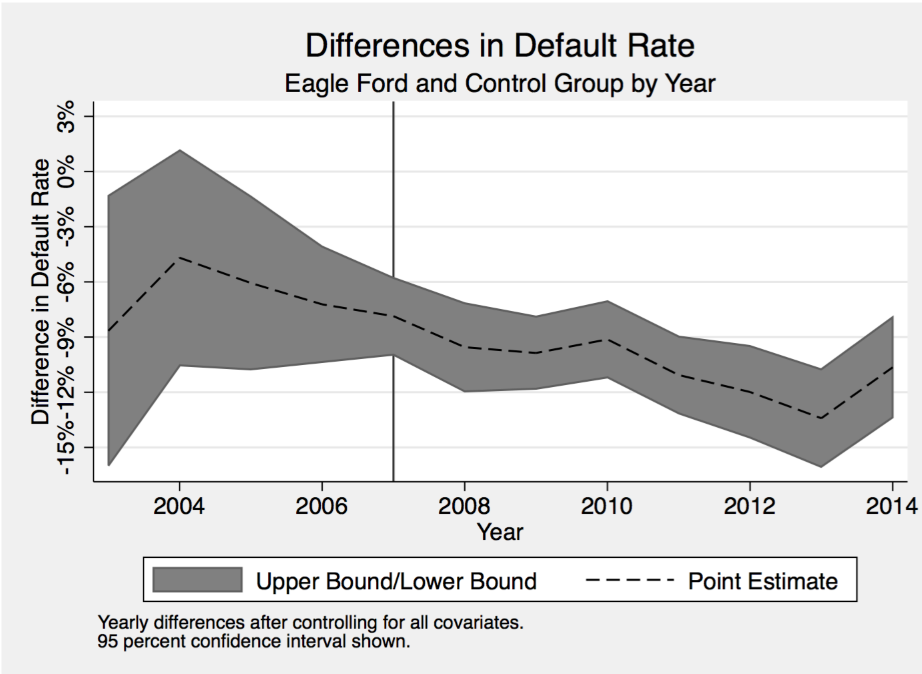


Figure A8: Eagle Ford: Comparison of Average Difference in Default Rates of Mortgages in Shale and Non-Shale Areas by Year



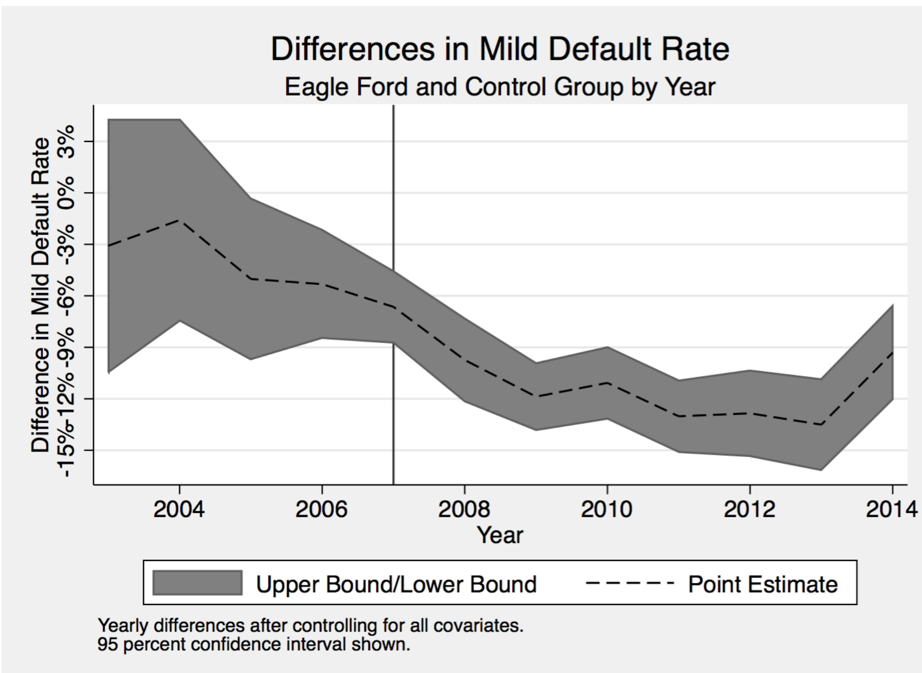
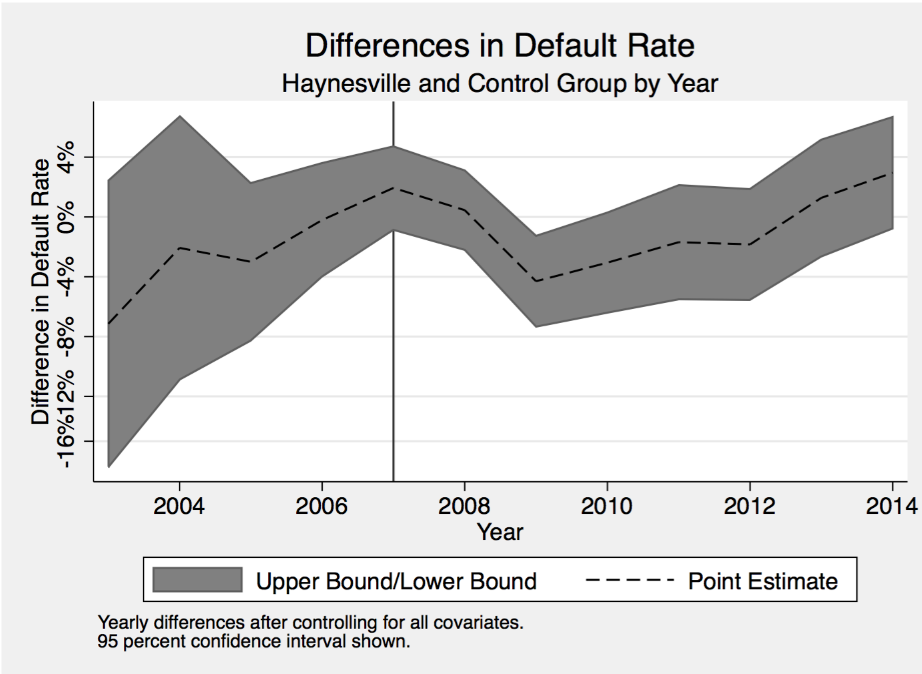


Figure A9: Haynesville: Comparison of Average Difference in Default Rates of Mortgages in Shale and Non-Shale Areas by Year



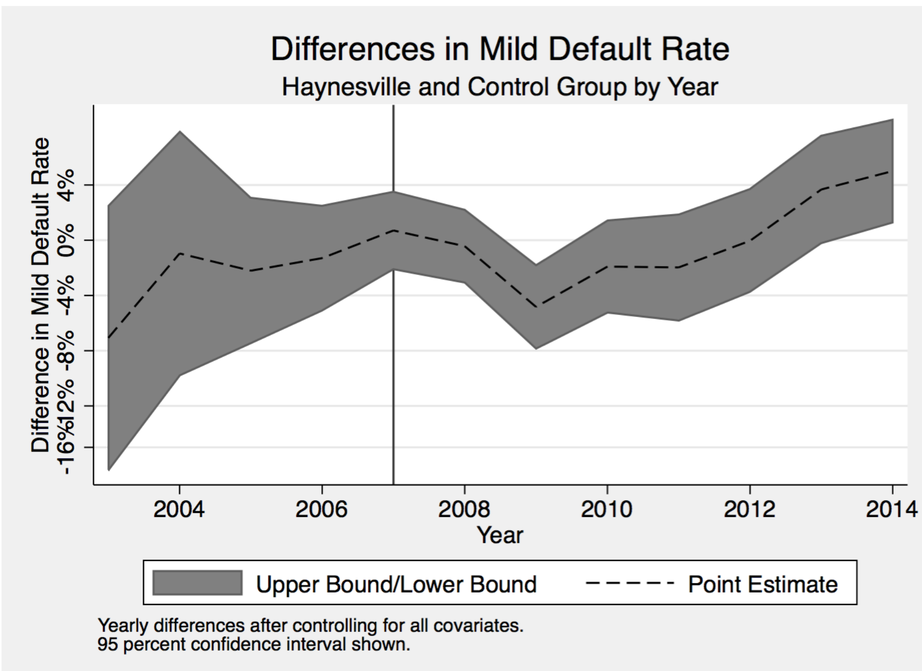
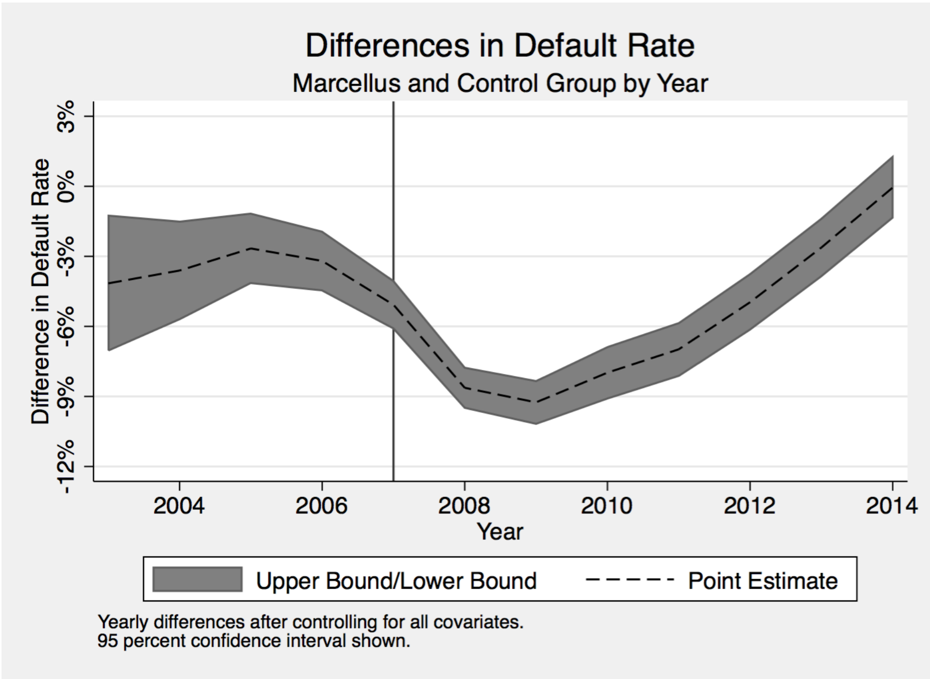


Figure A10: Marcellus: Comparison of Average Difference in Default Rates of Mortgages in Shale and Non-Shale Areas by Year



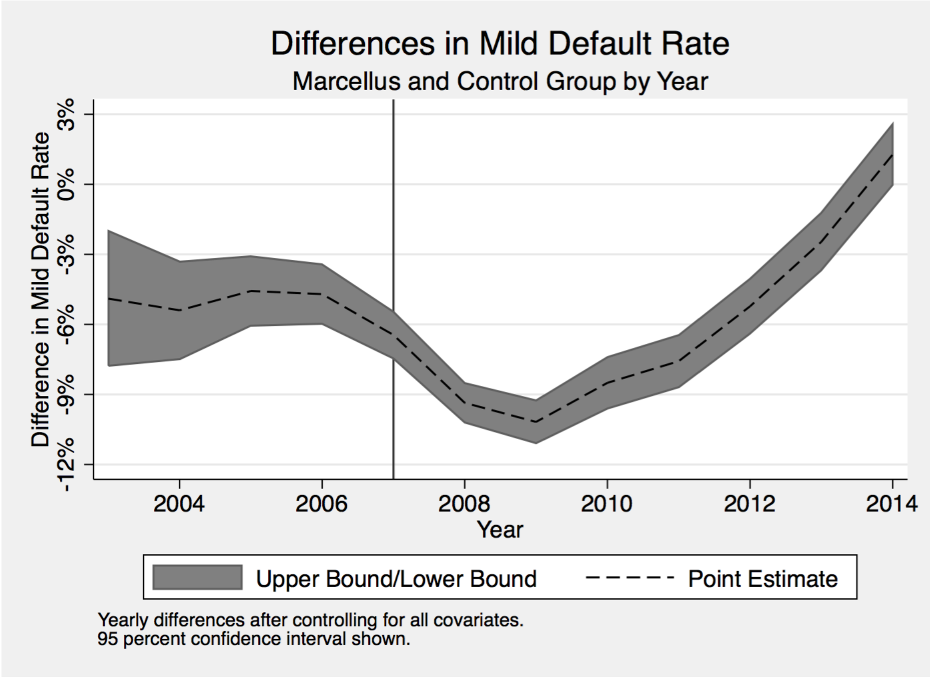
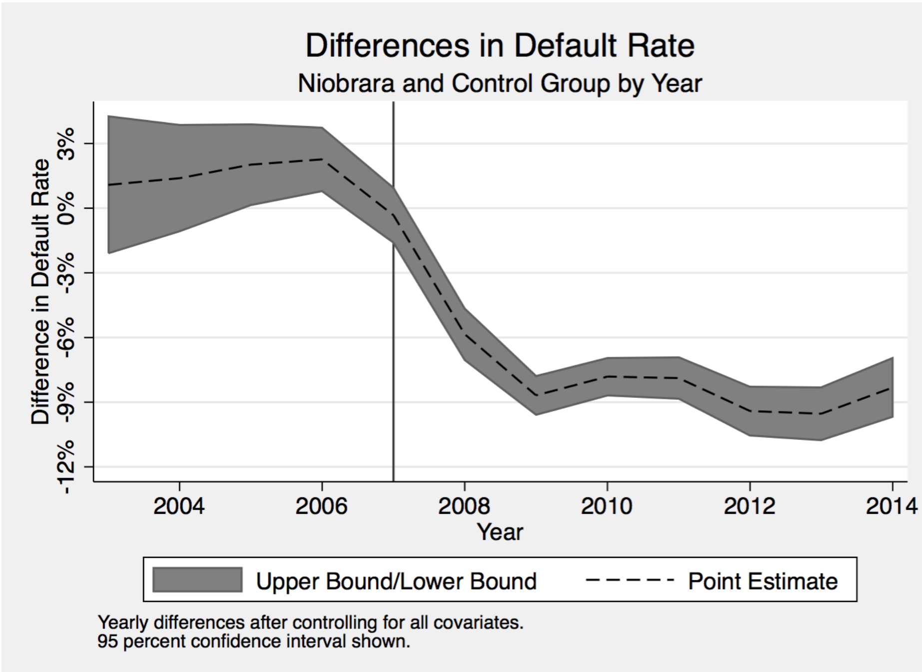


Figure A11: Niborara: Comparison of Average Difference in Default Rates of Mortgages in Shale and Non-Shale Areas by Year



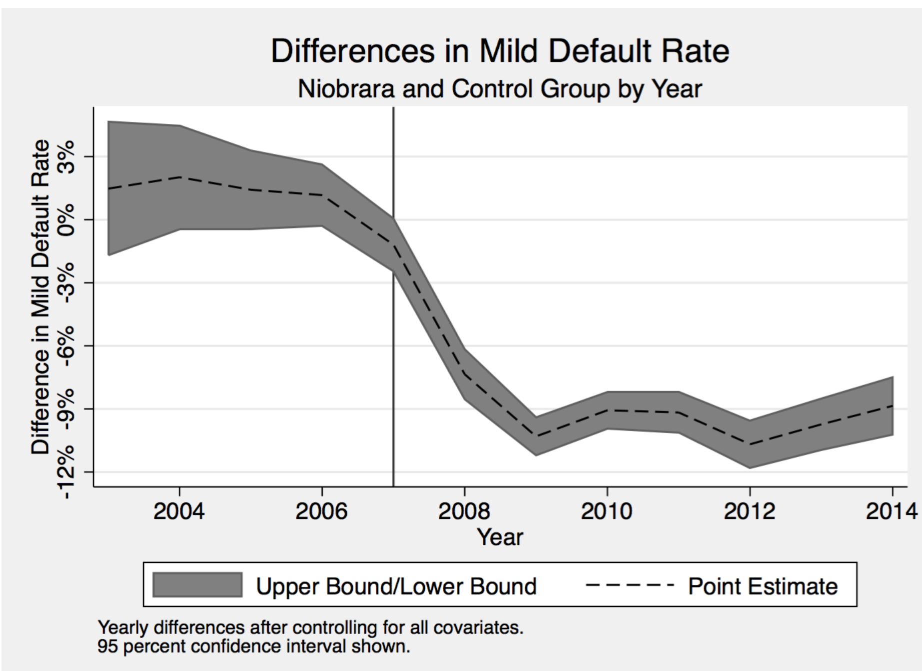


Figure A12: Utica: Comparison of Average Difference in Default Rates of Mortgages in Shale and Non-Shale Areas by Year