Do Restrictions on Home Equity Extraction Contribute to Lower Mortgage Defaults? Evidence from a Policy Discontinuity at the Texas Border

Anil Kumar

Online Appendix

Appendix A: Additional Robustness Tests

Informal test of precise manipulation of location around the Texas border

A crucial identification assumption for RD validity is that individuals with a strong taste for mortgage borrowing do not precisely manipulate their location around the discontinuity threshold (the Texas border). As discussed earlier, the 1997 constitutional amendment in Texas significantly relaxed home equity borrowing restrictions by opening the door for homeowners to tap into their home equity through second mortgages or cash-out refinancing, subject to an 80 percent cap on CLTV. If individuals move in response to restrictions on home equity borrowing, then the 1997 amendment should lead to increased net outflow from neighboring states to Texas, relative to net outflows to the states other than Texas. I use IRS data on state-to-state migration of tax returns to present tentative evidence that borrowers did not manipulate their location in response to the 1997 amendment that eased access to home equity.

Table A2 shows that from 1993 to 1996, before the 1997 amendment, net outflow of tax returns from neighboring states to Texas was 0.08 percent of all non-migrant returns in these states. The outflows increased by 0.12 percentage points to 0.20 percent after the law change. On the other hand, net outflows to other states increased by an even larger amount-0.50 percentage points. This casts doubt on the hypothesis that ease of obtaining credit against home equity in Texas may have been associated with increased net migration from neighboring states to Texas.[1]

Additional robustness checks for county-level estimates

Tables A3 through A7 examine robustness of county-level estimates to additional covariates, an alternative estimation sample, and nonparametric estimation methods. To get a sense of the extent to which the Texas policy may have lowered incidence of underwater mortgages, Table A3 reports linear RD regressions of share of mortgages underwater by 20 percent or more. Table A4 reports multidimensional RD estimates similar to Table 4 for nonprime mortgages but

[1] A more elaborate difference-in-differences specification controlling for other interstate differences in characteristics also reveals no significant difference in net outflow into Texas relative to other states before vs. after the 1997 law change that eased borrowing against home equity. Results are available on request from the author.

additionally controls for state-specific policy differences: whether the state requires judicial foreclosure and whether the state allows redemption. To account for any remaining differences in state-level policy that affect housing supply, I also control for house price elasticity from Saiz (2010).[2] The estimates are statistically similar but larger in magnitude than those in Table 4. Table A5 presents traditional RD estimates using nonparametric methods in Calonico et al. (2014a, 2014b) for the data-driven MSE-Optimal bandwidth without covariates (column 1) and with covariates (column 2).

Identification of the treatment effect using cross-border comparisons between Texas and neighboring states can be further improved by restricting the estimation sample to just contiguous border counties (Dube et al., 2010). In this case, estimation is based on stacked data consisting of all possible contiguous county pairs. In addition to other covariates used in previous county-level specifications, we can now include county-pair fixed effects. An added advantage is that contiguous counties just outside the Texas border are plausibly better controls for Texas' counties, obviating the need to use RD specifications. Confirming this expectation, Table A6 shows that the estimated impact of the Texas policy on nonprime mortgage default rates is strikingly similar across specifications without the RD polynomial in column (1) and with post-double LASSO selected RD polynomial specifications in columns (2) and (3). To keep the model simple, regressions in Table A6 control for a parsimonious set of baseline covariates similar to Table 2. Table A7 reports RD estimates of the effect of the Texas policy on mortgage default rates for even smaller distance bands on either side of the Texas border. Table A8 explores the extent of discontinuity in other covariates for the 10-mile bandwidth and for the MSE-Optimal bandwidths. Finally, Table A9 in Appendix A compares the covariate-adjusted multidimensional RD estimates reported in Tables 3 and 4 with those without covariates and presents identified sets using formulas derived in Oster (2017).

[2] The standard errors in Table A2 should be viewed as a lower bound as estimates have been clustered at the county level and not at the state level. The correct approach would be to cluster standard errors at the state-level house prices (Cameron and Miller, 2013; Cameron et al., 2011; Donald and Lang, 2007; Wooldridge, 2003). However, this is infeasible because the number of clusters (states) is just 5.

Table A1: Impact of Texas Home Equity Regulation on Serious Mortgage Delinquency using State Level Data from 2007-2011

	(1) Prime	(2) Prime	(3) SubPrime	(4) SubPrime
Texas	-0.988**	-0.555**	-3.594**	-1.768**
	(0.218)	(0.249)	(0.875)	(0.641)
Initial FICO	-0.017	-0.015	-0.024	-0.033
	(0.013)	(0.011)	(0.055)	(0.042)
Lagged House Price Growth	-0.069**	-0.067**	-0.210**	-0.191**
	(0.016)	(0.015)	(0.037)	(0.024)
Unemployment Rate	0.547**	0.535**	1.497**	1.601**
	(0.082)	(0.086)	(0.238)	(0.178)
Log Median Household Income	0.764	0.230	6.969	8.716**
	(1.041)	(1.436)	(5.505)	(3.627)
Judicial		0.869**		4.505**
		(0.356)		(0.813)
Redemption		-0.112		-0.213
		(0.232)		(1.004)
Housing Elasticity		-0.259		-0.614
		(0.199)		(0.422)
Observations	255	245	255	245
R-Sq	0.66	0.70	0.63	0.78

Note: Standard errors clustered by state are reported in parenthesis. Estimates are based on simple linear regression of state-level subprime default rate from 2007 to 2011 on a Texas dummy and other state level covariates listed in the table. Estimates are weighted by state employment. Sources: MBA data on delinquencies from Haver analytics; house price growth from FHFA; unemployment rate and median household income from BLS/LAUS; initial FICO based on state-level average from ABS data from RADAR data warehouse. See the data section on page 8 for sources of data on other covariates.

Table A2: Migration of Tax Returns from/to Neighboring States (AR, LA, NM, and OK) 3 Years Before and After 1997 Law Relaxing Mortgage Borrowing Restrictions (All outflows and inflows measured as percent of non-migrant returns)

	(1)	(2)	(3)
	Before 1997 (1993-1996)	After 1997 (1998-2001)	***After minus Before***
A. Outflow			
To Texas	0.87	0.91	**0.04**
To Other States	2.72	2.75	**0.03**
Texas minus Other States	**-1.85**	**-1.84**	**0.01**
B. Inflow			
From Texas	0.79	0.71	**-0.08**
From Other States	2.98	2.51	**-0.47**
Texas minus Other States	**-2.19**	**-1.80**	**0.39**
C. Net Migration (Outflow-Inflow)			
To Texas	0.08	0.20	**0.12**
To Other States	-0.26	0.24	**0.50**
Texas minus Other States	**0.34**	**-0.04**	**-0.38**

Note: This table is based on state level IRS data on state-to-state migration of tax returns calculated using online tools at taxfoundation.org.

Table A3: Linear RD Regressions of Share of Mortgages Underwater by 20 Percent or More

	(1) <25 miles	(2) <50 miles	(3) <75 miles	(4) <100 miles	(5) All
Texas	-6.715	-10.161*	-15.771**	-12.177**	1.629
	(12.580)	(5.034)	(4.061)	(3.122)	(2.129)
Year Effects	Yes	Yes	Yes	Yes	Yes
Linear Polynomial in Distance	Yes	Yes	Yes	Yes	Yes
Other Covariates	Yes	Yes	Yes	Yes	Yes
Observations	73	139	246	351	898
N_counties	17.00	32.00	57.00	83.00	204.00
R-Sq	0.31	0.12	0.29	0.34	0.20

*Significant at 10% level; **Significant at 5% level. Robust standard errors clustered by county are in parenthesis. Results presented are from linear regression of share of mortgages underwater by 20 percent or more at county-year level from 2007 to 2011 on the Texas dummy, a linear RD polynomial in minimum distance to the Texas border (normalized to zero at the border), and other county-level baseline covariates: county unemployment rate, 1-year lagged log house price change (LaggedΔHPI), county-level initial FICO score, and year effects. Estimates weighted by number of loans in each county-year cell. Data from Holmes (1998) was used to get distances of county centroid to the Texas border with respective states. Results are based on data on nonprime mortgages from ABS database and CoreLogic TrueLTV database available from RADAR data warehouse.

Table A4: Robustness of Multidimensional RD to Controlling for State Level Policy Variables
(***Dependent Variable: County-Level Default Rate)***
(Data: ABS Data on Nonprime Mortgages Grouped to County Level)

	(1)	(2)	(3)	(4)	(5)
Distance Band at Texas Border	<25 miles	<50 miles	<75 miles	<100 miles	All
Panel A: Linear Polynomial in Latitude and Longitude					
Texas	-7.378**	-5.336**	-3.313*	-2.022	-3.087**
	(2.315)	(1.620)	(1.768)	(1.424)	(1.249)
Panel B: Quadratic Polynomial in Latitude and Longitude					
Texas	-7.454**	-5.214**	-3.600**	-2.303	-4.666**
	(2.272)	(1.648)	(1.589)	(1.413)	(1.364)
Panel C: Cubic Polynomial in Latitude and Longitude					
Texas	-10.987**	-8.035**	-4.377**	-4.034*	-6.068**
	(2.062)	(1.836)	(2.179)	(2.202)	(1.381)
Panel D: Polynomial in Latitude and Longitude using post-double-LASSO §					
Texas	-6.465**	-4.806**	-3.878**	-2.476*	-3.087**
	(2.003)	(1.499)	(1.593)	(1.331)	(1.249)
LASSO Selected Polynomial Terms	*None*	*None*	*None*	*None*	*X,Y*
Observations	310	569	829	1073	2252
Counties	64	117	170	219	456
R-Square	0.8939	0.8900	0.8988	0.9061	0.8597
Other Covariates	Yes	Yes	Yes	Yes	Yes
State Policy Vars	Yes	Yes	Yes	Yes	Yes
Year Effects	Yes	Yes	Yes	Yes	Yes
Border FE	Yes	Yes	Yes	Yes	Yes

*Significant at 10% level; **Significant at 5% level. Robust standard errors clustered by county in parenthesis. The dependent variable mortgage default is defined as share of mortgages 90-plus days delinquent or in foreclosure or REO. Results presented are from linear regression of county-year level mortgage default rates from 2007 to 2011 on the Texas dummy and multidimensional RD polynomial in latitude and longitude. Other county-level baseline covariates included are the county unemployment rate, 1-year lagged log house price change (LaggedΔHPI), county-level initial FICO score, share of mortgages with initial CLTV 80 percent or higher, county-level log median household income, share of adjustable rate mortgages, share of cash-out refinance mortgages, and average county-level mortgage denial rate between 2000 and 2006, year effects, and state border-segment fixed effects. Estimates weighted by number of loans in each county-year cell. The coefficient on the Texas dummy should be interpreted as the discontinuity in mortgage default rate on Texas side of the border vis-a-vis NM, OK, AR, and LA side of the border. Data from Holmes (1998) was used to get distances of county centroid to the Texas border with respective states. Data on county-level nonprime default rates and other mortgage characteristics are from ABS database on nonprime mortgages from CoreLogic. [§]See Appendix C for details on LASSO selection procedure. State-specific policy variables included are dummies for judicial foreclosure, whether the state allows redemption, and state-level house price elasticity.

Table A5: Conventional, Robust and Bias-Corrected Regression Discontinuity Estimates at Data-driven Mean Squared Error (MSE)-Optimal Bandwidth Choices

(Dependent Variable: County-Level Nonprime Mortgage Default Rate)

	(1) Without Covariates	(2) Covariate-Adjusted
Conventional	-5.129**	-5.604**
	(1.726)	(1.299)
Bias-corrected	-6.165**	-5.530**
	(1.726)	(1.299)
Robust	-6.165**	-5.530**
	(1.951)	(1.881)
Kernel	Triangular	Triangular
RD Polynomial	Local Linear	Local Linear
MSE-Optimal Bandwidth	117.357	78.115
N	2252	2252
Effective N (left of cutoff)	602	377
Effective N (right of cutoff)	611	481

*Significant at 10% level; **Significant at 5% level. All calculations are based on county-level ABS data from 2007 to 2011. Estimates based on “rdrobust” software described in Calonico et al. (2014a, 2014b) and Calonico et. al (2017). MSE-Optimal bandwidth based on the implementation in Calonico et al. (2014a) of the simple plug-in bandwidth proposed in Imbens and Kalyanaraman (2012). Estimates in column (2) adjusted for year dummies and the following covariates: initial FICO, lagged house price change, mortgage denial rate, share of borrowers with initial CLTV 80 percent or higher, share of ARMs, unemployment rate, and median household income.

Table A6: Results Using Contiguous Border Counties Sample
(***Dependent Variable: County-Level Default Rate)***
(Data: ABS Data on Nonprime Mortgages Grouped to County Level)

	(1) OLS	(2) LASSO	(3) LASSO
Texas	-3.735**	-3.346**	-3.012**
	(0.718)	(0.730)	(1.297)
Multidimensional RD	No	Yes	No
Traditional RD	No	No	Yes
Other Covariates	Yes	Yes	Yes
County Pair Effects	Yes	Yes	Yes
Year Effects	Yes	Yes	Yes
N	637	637	637
N_counties	76	69	69
R-Sq	0.9460	0.9461	0.9460

*Significant at 10% level; **Significant at 5% level. Robust standard errors clustered by county in parenthesis. The dependent variable mortgage default is defined as share of mortgages 90-plus days delinquent or in foreclosure or REO. Results presented are from linear regression of county-year level mortgage default rates from 2007 to 2011 on the Texas dummy and a linear RD polynomial in minimum distance to the Texas border (normalized to zero at the border). Other county-level baseline covariates included are the county unemployment rate, 1-year lagged log house price change (LaggedΔHPI), county-level initial FICO score, county-pair fixed effects, year effects. Estimation sample was restricted to contiguous border counties. Estimates weighted by number of loans in each county-year cell. The coefficient on the Texas dummy should be interpreted as the discontinuity in mortgage default rate on Texas side of the border vis-a-vis NM, OK, AR, and LA side of the border. County-level nonprime mortgage default rates are based on ABS database from RADAR data warehouse.

Table A7: RD Estimates of the Effect of the Texas Policy for Smaller Distance Bands on Either Side of the Texas Border

(***Dependent Variable: County-Level Default Rate)***

	(1) <10 miles	(2) <10 miles	(3) <15 miles	(4) <15 miles	(5) <20 miles	(6) <20 miles
Panel A: All Mortgages						
Texas	-3.799**	-4.714**	-1.795**	-2.282**	-2.086*	-2.328*
	(1.158)	(1.720)	(0.823)	(0.955)	(1.180)	(1.195)
Observations	72	72	184	184	280	280
N_counties	15.00	15.00	38.00	38.00	58.00	58.00
R-Sq	0.89	0.90	0.74	0.75	0.55	0.63
Panel B: Nonprime Mortgages						
Texas	-11.031**	-10.317**	-5.932**	-3.479	-6.536**	-2.899
	(2.131)	(2.014)	(2.463)	(2.184)	(3.207)	(2.266)
Observations	72	72	184	184	280	280
N_counties	15.00	15.00	38.00	38.00	58.00	58.00
R-Sq	0.89	0.94	0.80	0.83	0.70	0.75
Linear in Distance	Yes	Yes	Yes	Yes	Yes	Yes
Year Effects	Yes	Yes	Yes	Yes	Yes	Yes
Baseline Covariates	No	Yes	No	Yes	No	Yes

*Significant at 10% level; **Significant at 5% level. Robust standard errors clustered by county in parenthesis. The dependent variable mortgage default is defined as share of mortgages 90-plus days delinquent or in foreclosure or REO. Results presented are from linear regression of county-year level mortgage default rates from 2007 to 2011 on the Texas dummy and a linear RD polynomial in minimum distance to the Texas border (normalized to zero at the border). Other county-level baseline covariates included are the county unemployment rate, 1-year lagged log house price change (LaggedΔHPI), county-level initial FICO score, and year effects. Estimates weighted by number of loans in each county-year cell. The coefficient on the Texas dummy should be interpreted as the discontinuity in mortgage default rate on Texas side of the border vis-a-vis NM, OK, AR, and LA side of the border. Data from (Holmes, 1998) was used to get distances of county centroid to the Texas border with respective states. Results in Panel A are based on data on all residential mortgages from McDash/Lender Processing Services (LPS) and Panel B on data on nonprime mortgages from ABS database.

Table A8: Estimated Regression Discontinuity in Covariates

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Initial FICO Score	Log House Price Change	Mortgage Denial Rate	Initial-CLTV 80 Percent or Higher	Debt-to-Income Ratio	Share of ARMs	Log Appraisal Amount at Loan Origination	Unemployment Rate	Log Median Household Income
Panel A: Within 10-Mile Bandwidth									
Texas	11.001	-0.037	-4.102	0.739	4.006	-0.108	0.128	6.178**	-0.584
	(21.356)	(0.021)	(5.817)	(3.538)	(2.527)	(0.070)	(0.164)	(1.537)	(0.284)
Panel B: Within Covariate-Adjusted MSE-Optimal 78-Mile Bandwidth##									
Texas	10.683	-0.004	-5.542	-1.199	0.677	-0.062**	0.216	1.541	0.259
	(11.725)	(0.012)	(4.878)	(3.821)	(0.411)	(0.021)	(0.217)	(0.862)	(0.295)
Panel C: Within Non-Covariate-Adjusted MSE-Optimal 117-Mile Bandwidth##									
Texas	21.364	-0.011	-6.559	0.716	0.464	-0.023	0.316	1.313	0.246
	(11.175)	(0.008)	(4.379)	(3.316)	(0.368)	(0.023)	(0.199)	(0.682)	(0.240)

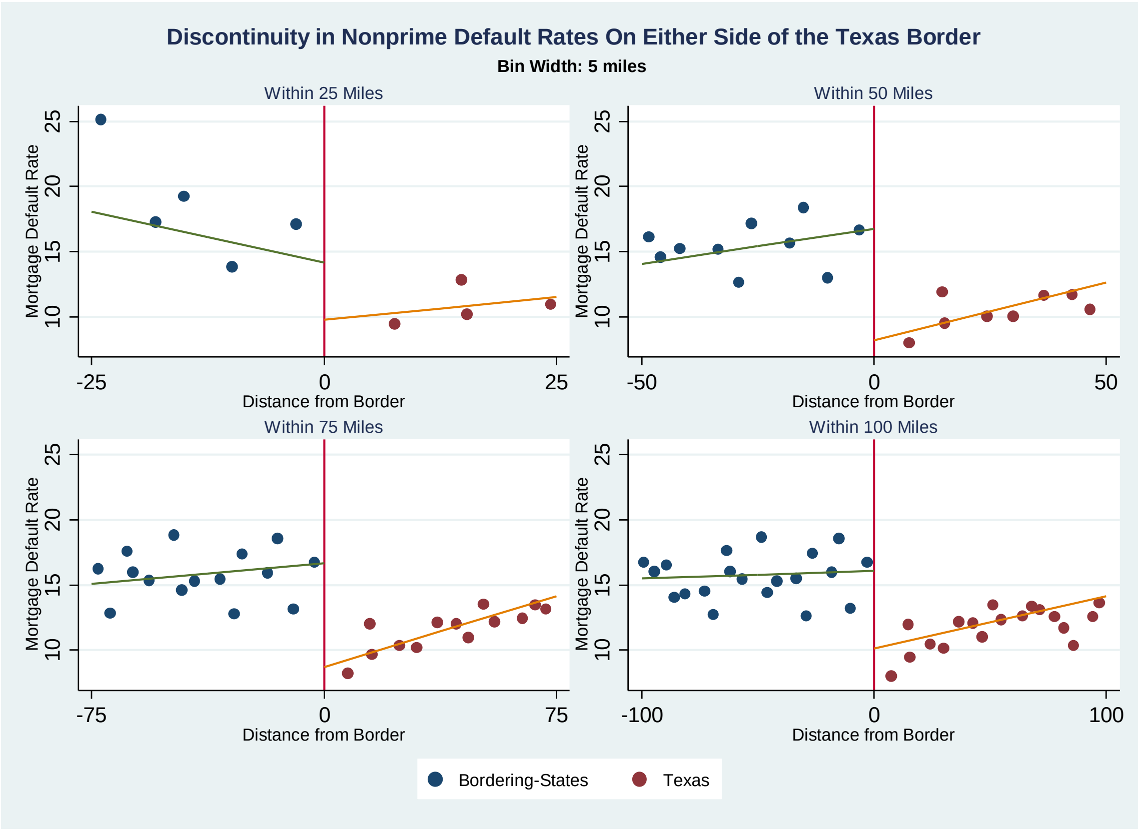
Note: **Significant at 5% level. ##MSE-Optimal bandwidth based on the implementation in Calonico et al. (2014a) of the simple plug-in bandwidth proposed in Imbens and Kalyanaraman (2012) (see Table A5). Robust standard errors clustered by county in parenthesis. All calculations are based on county-level data from 2007 to 2011. The table shows RD estimates from a simple regression of the relevant variable—on the Texas dummy and a linear RD polynomial in the running variable (distance from Texas border) and year dummies. All estimates are weighted by county-year level number of nonprime loans. The coefficient on the Texas dummy reported should be interpreted as the discontinuity in the covariate on Texas side of the border vis-a-vis NM, OK, AR, and LA side of the border. Sources of data: county-level initial FICO, initial CLTV, Debt-to-Income (DTI) Ratio, Percent ARM, and Log appriasal amount at origination calculated using ABS data from RADAR data warehouse; county unemployment rate and median household income from BLS/LAUS; county-level house price index from CoreLogic; mortgage denial rates calculated using HMDA data available from the Urban Institute.

Table A9: Coefficient Stability of Multidimensional RD and Identified Sets Using Oster (2017)

	(1)	(2)	(3)	(4)	(5)	(6)
Bandwidth	<25 miles	<25 miles	<50 miles	<50 miles	<75 miles	<75 miles
Panel A: All Mortgages						
Linear Polynomial						
Texas	-0.73	-1.53	-1.38	-1.40	-0.52	-1.11
	(0.52)	(0.36)	(0.46)	(0.38)	(0.49)	(0.41)
R-Squared	0.70	0.86	0.66	0.86	0.54	0.86
Identified set		**[-2.33, -1.53]**		**[-1.42, -1.40]**		**[-1.37, -1.11]**
Quadratic Polynomial						
Texas	-0.59	-1.19	-0.94	-1.19	-0.82	-1.01
	(0.46)	(0.31)	(0.37)	(0.33)	(0.52)	(0.36)
R-Squared	0.74	0.88	0.70	0.88	0.56	0.89
Identified set		**[-2.40, -1.19]**		**[-1.50, -1.19]**		**[-1.09, -1.01]**
Cubic Polynomial						
Texas	-1.42	-1.34	-1.05	-1.48	-1.80	-1.42
	(0.52)	(0.35)	(0.57)	(0.39)	(0.55)	(0.33)
R-Squared	0.82	0.90	0.74	0.88	0.63	0.92
Identified set		**[-1.34, -0.42]**		**[-1.96, -1.48]**		**[-1.42, -1.27]**
Panel B: Nonprime						
Linear Polynomial						
Texas	-3.67	-4.61	-3.76	-4.10	-2.06	-3.43
	(1.12)	(1.16)	(0.88)	(0.92)	(0.92)	(1.02)
R-Squared	0.81	0.89	0.82	0.89	0.76	0.89
Identified set		**[-8.79, -4.61]**		**[-8.59, -4.10]**		**[-5.93, -3.43]**
Quadratic Polynomial						
Texas	-2.51	-3.91	-2.50	-3.81	-2.76	-3.07
	(1.12)	(1.22)	(0.72)	(0.83)	(0.91)	(0.91)
R-Squared	0.83	0.90	0.85	0.89	0.78	0.90
Identified set		**[-10.2, -3.91]**		**[-11.2, -3.8]**		**[-3.82, -3.07]**
Cubic Polynomial						
Texas	-4.02	-5.61	-3.74	-4.8	-4.84	-4.62
	(1.17)	(1.45)	(1.1)	(1.00)	(0.85)	(0.87)
R-Squared	0.85	0.90	0.86	0.89	0.83	0.91
Identified set		**[-15.0, -5.61]**		**[-13.2, -4.8]**		**[-4.62, -3.55]**
Other Covariates	No	Yes	No	Yes	No	Yes

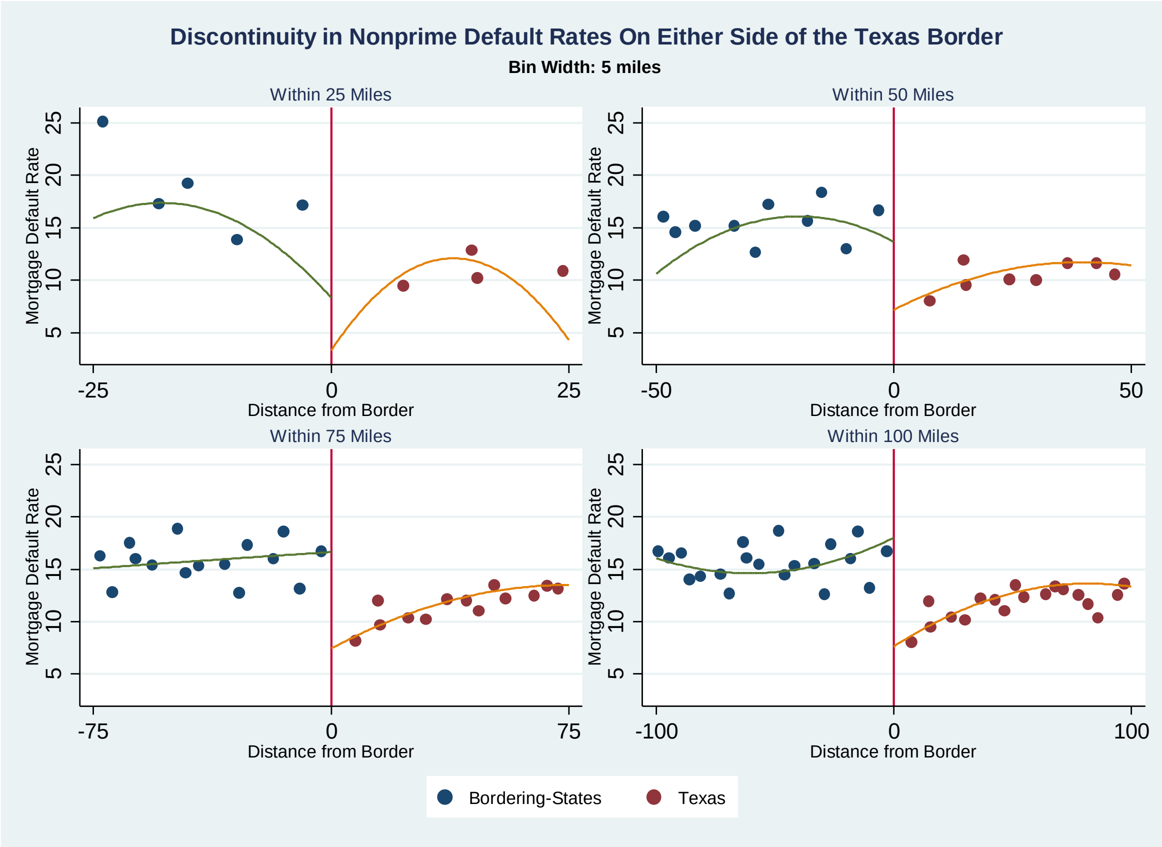
Note: Identified set calculated using formulas based on unrestricted estimator derived in Oster (2017). The bounds assume that selection on unobservables equals that on observables and that controlling for unobservables could potentially increase R-square to 1. All columns include year effects. See notes to Tables 3 and 4 for other covariates included in columns 2, 4, and 6 and other estimation details and data sources. The row labelled Texas presents RD estimates on the Texas coefficient in the multidimensional RD specification.

Figure A1



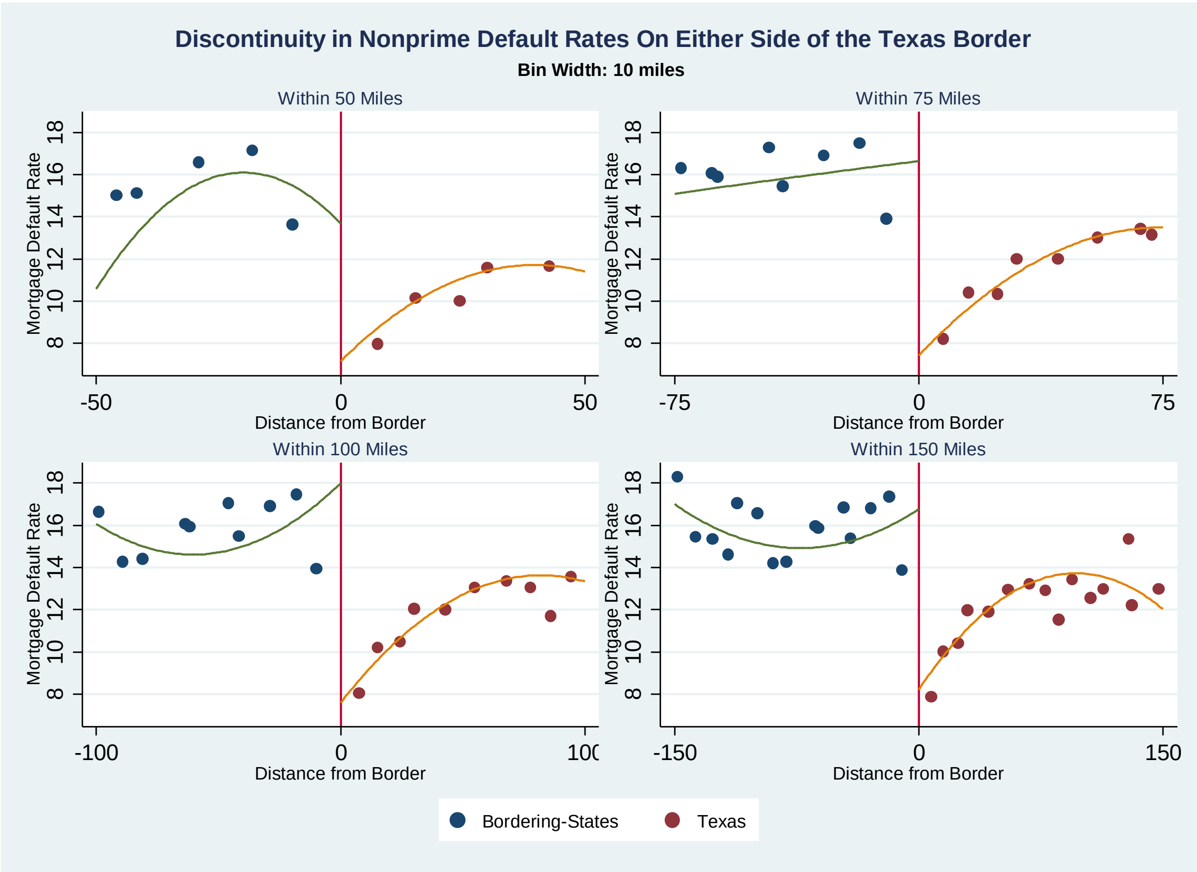
Note: The figure plots the conditional mean of the county-level nonprime mortgage default rate from 2007 to 2011 (controlling for baseline covariates: unemployment, initial FICO, and house price change) within 5-mile wide bins. Linear fitted lines are based on regression of county-level mortgage default rate (residualized by subtracting the prediction from a regression of mortgage default rate on baseline covariates) from 2007 to 2011 on a linear polynomial in distance. Mortgages in default are defined as those 90-plus days delinquent or in foreclosure or real estate owned (REO). All estimates are weighted by county-level number of nonprime loans. Sources of data are: county-level nonprime default rate and initial FICO calculated using ABS data from RADAR data warehouse; county unemployment rate from BLS/LAUS; county-level house price index from CoreLogic.

Figure A2



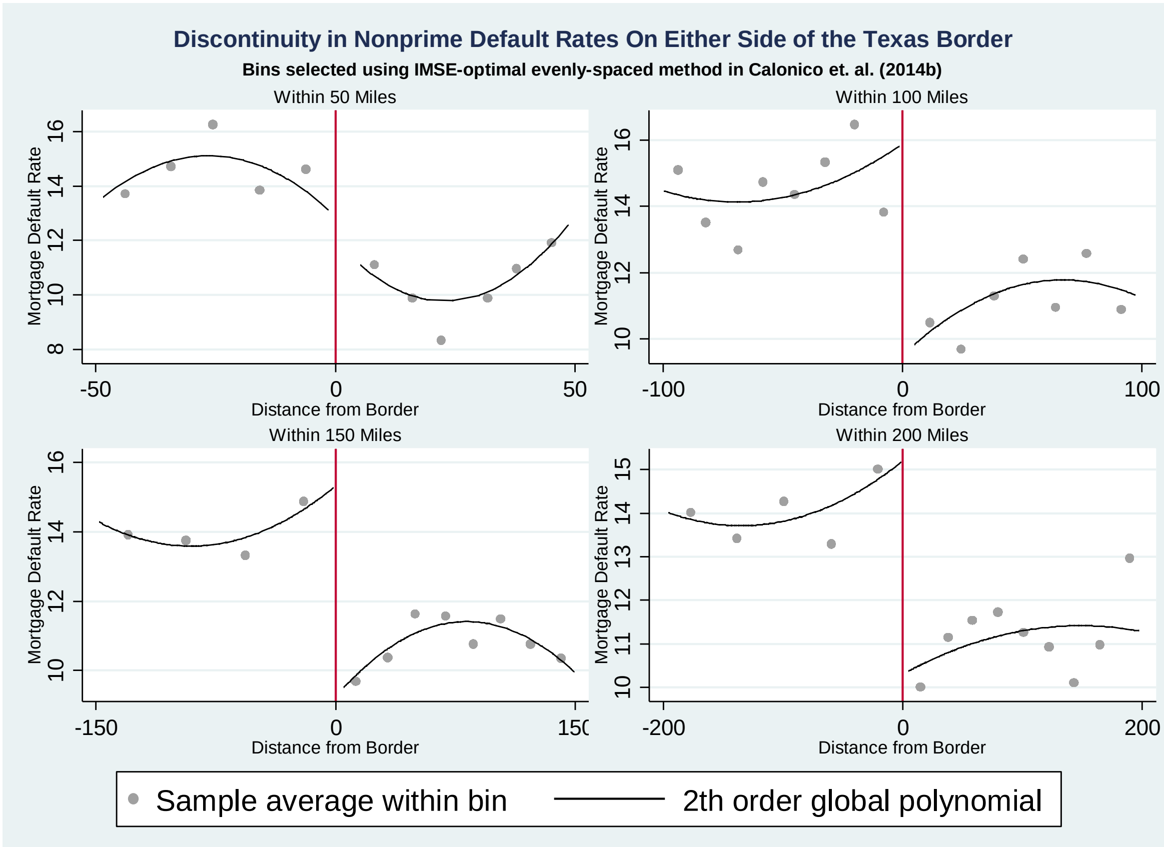
Note: The figure plots conditional mean of county-level nonprime mortgage default rate from 2007 to 2011 (controlling for baseline covariates: unemployment, initial FICO, and house price change) within 5-mile wide bins. Quadratic fitted lines are based on regression of county-level mortgage default rate (residualized by subtracting the prediction from a regression of mortgage default rate on baseline covariates) from 2007 to 2011 on a quadratic polynomial in distance. Mortgages in default are defined as those 90-plus days delinquent or in foreclosure or real estate owned (REO). All estimates are weighted by county-year-level number of nonprime loans. Data sources: county-level nonprime default rate and initial FICO calculated using ABS data from RADAR data warehouse; county unemployment rate from BLS/LAUS; county-level house price index from CoreLogic.

Figure A3



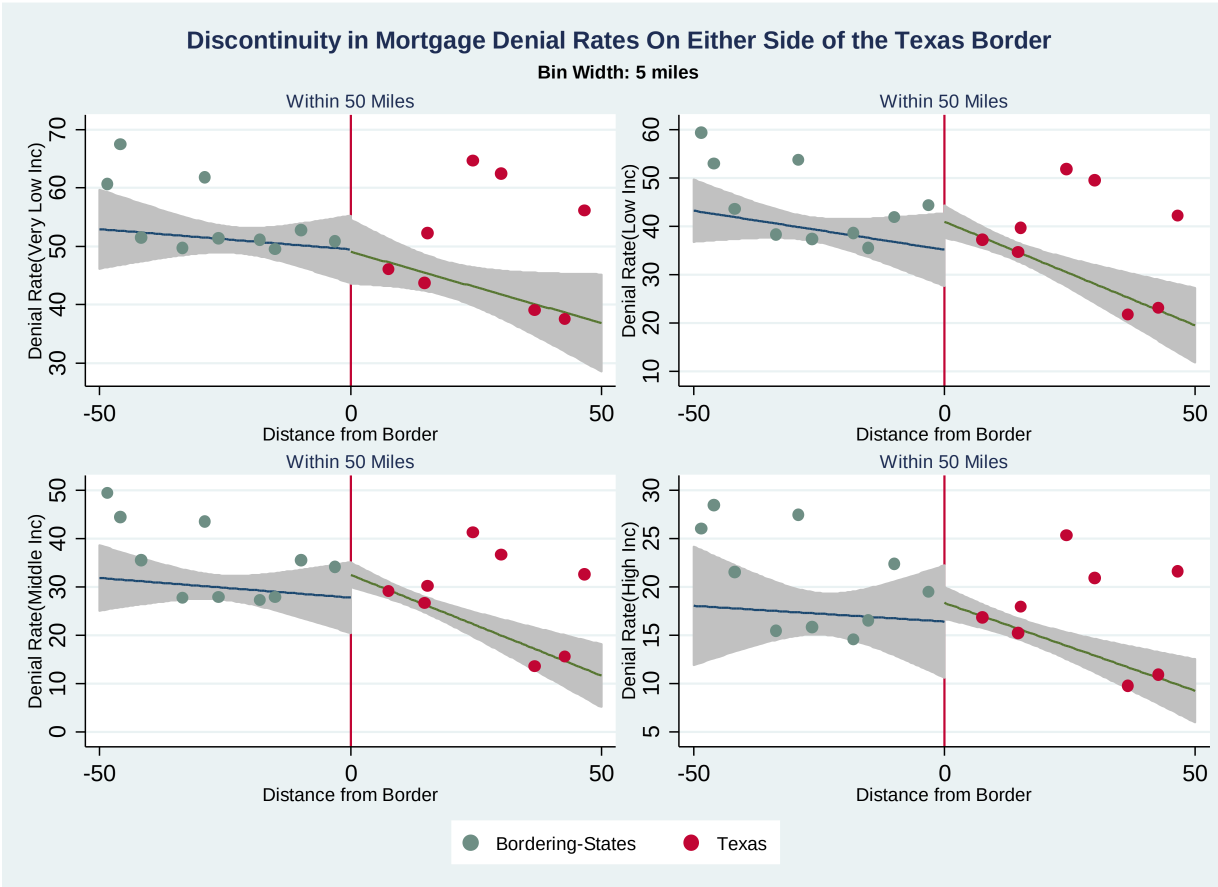
Note: The figure plots conditional mean of county-level nonprime mortgage default rate from 2007 to 2011 (controlling for baseline covariates: unemployment, initial FICO, and house price change) within 10-mile wide bins. Quadratic fitted lines are based on regression of county-level mortgage default rate (residualized by subtracting the prediction from a regression of mortgage default rate on baseline covariates) from 2007 to 2011 on a quadratic polynomial in distance. Mortgages in default are defined as those 90-plus days delinquent or in foreclosure or real estate owned (REO). All estimates are weighted by county-year-level number of nonprime loans. Data sources: county-level nonprime default rate and initial FICO calculated using ABS data from RADAR data warehouse; county unemployment rate from BLS/LAUS; county-level house price index from CoreLogic.

Figure A4



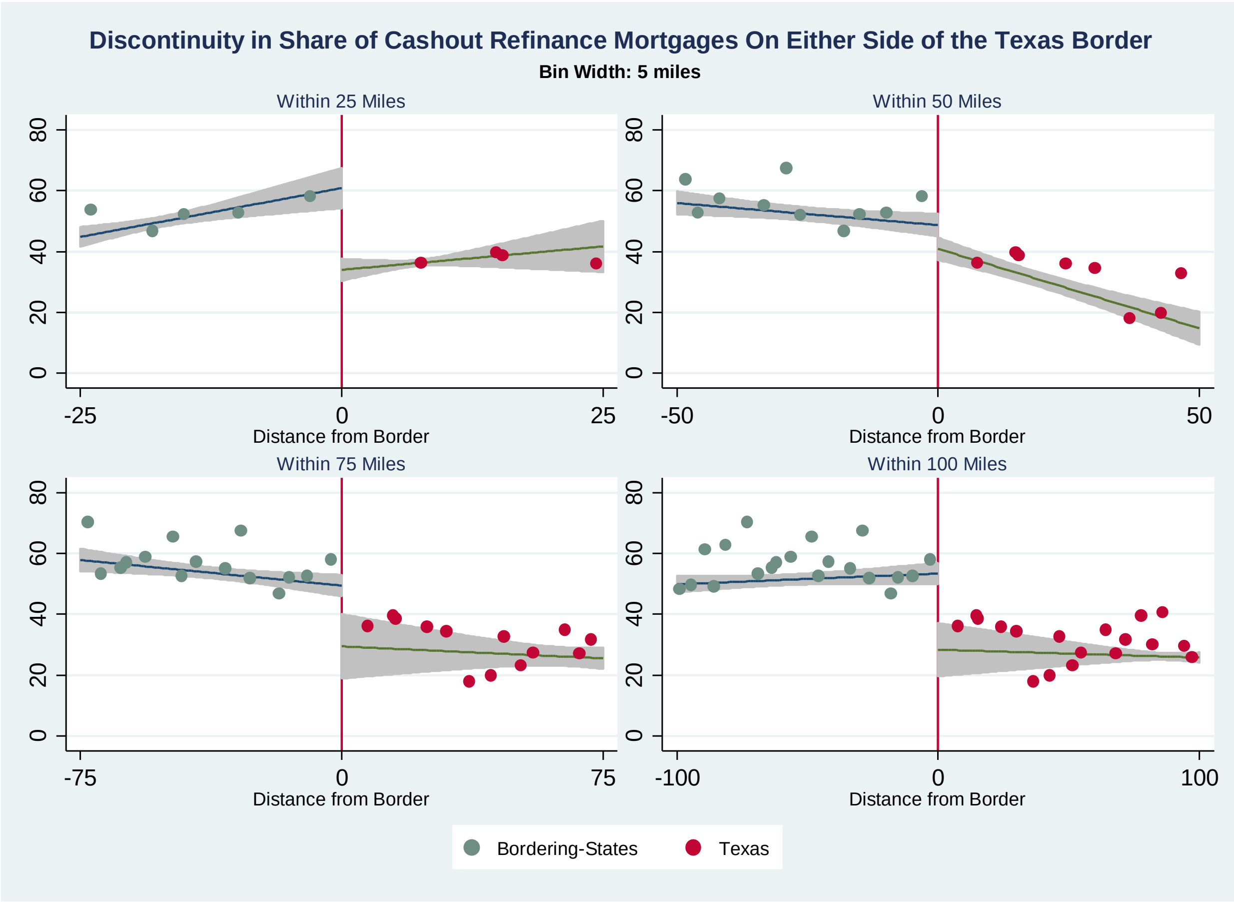
Note: The figure plots binned means of residualized county-level nonprime mortgage default rate from 2007 to 2011 (controlling for unemployment, initial FICO, and house price change) with bins selected using Calonico et al. (2014a, 2015). Quadratic fitted lines are based on regression of county-level mortgage default rate (residualized by subtracting the prediction from a regression of mortgage default rate on baseline covariates) from 2007 to 2011 on a quadratic polynomial in distance. Mortgages in default are defined as those 90-plus days delinquent or in foreclosure or real estate owned (REO). Data sources: county-level nonprime default rate and initial FICO calculated using ABS data from RADAR data warehouse; county unemployment rate from BLS/LAUS; county-level house price index from CoreLogic.

Figure A5



Note: The shaded region is 95 percent confidence intervals of the fitted lines. Scatterplots are of the simple unconditional mean within 5-mile bins of mortgage denial rate by income categories. Linear fitted lines are from a simple regression of the relevant variable on a linear polynomial in distance. All estimates are weighted by county-level number of nonprime loans. Data sources: mortgage denial rates calculated using HMDA data obtained from the Urban Institute.

Figure A6



Note: The shaded regions are 95 percent confidence intervals of the fitted lines. Scatter plots are of simple unconditional mean within 5-mile bins of county-level share of mortgages used for cash-out refinancing. Linear fitted lines are from a simple regression of the share of cash-out refinances on a linear polynomial in distance. All estimates are weighted by county-year-level number of nonprime loans. Data sources: mortgage denial rates calculated using HMDA data obtained from Urban Institute.

Appendix B: Placebo Tests

Placebo tests using other state borders

A central argument in the paper has been that cross-border discontinuity in nonprime mortgage default between Texas and the neighboring states exists primarily due to the Texas policy. Accounting for other state-level differences, such a large discontinuity in the nonprime mortgage default rate should not exist around the interstate borders of the remaining 47 contiguous states that allowed unrestricted access to home equity. In other words, the remaining state borders can serve as placebo borders. The estimated cross-border difference around the Texas border should then be in the lower tail of the 48 placebo estimates. The empirical CDF of the coefficient on the Texas treatment dummy can be interpreted as the p-value for the null hypothesis that the coefficient is zero.[3]

Figure B1 shows the empirical CDF of the 48 placebo estimates using just contiguous border county pairs and estimating a simple regression of the nonprime mortgage default rate on the placebo state dummy and a parsimonious set of key county-level covariates: the unemployment rate, $Lagged\Delta HPI$, and initial FICO score.[4] The Texas coefficient—plotted in the chart as a dashed vertical line—has an empirical CDF of 0.06, suggesting that the cross-border difference around the Texas border is significant at the 6 percent level. To guard against the possibility that this result doesn't just apply to contiguous county pairs, I repeat this analysis for all counties within 50 miles around the borders of the 48 contiguous states for four different RD polynomial specifications in Figure B2: linear and post-double-LASSO selected polynomials in latitude and longitude (left panel) as well as analogous specifications using traditional RD in distance to the state border (right panel). All four specifications yield p-values of well below 10 percent. Overall, the placebo tests presented in Appendix B bolster the conclusion that the Texas policy indeed significantly lowered nonprime mortgage defaults.

Placebo tests based on randomly drawn placebo cutoffs in the estimation sample

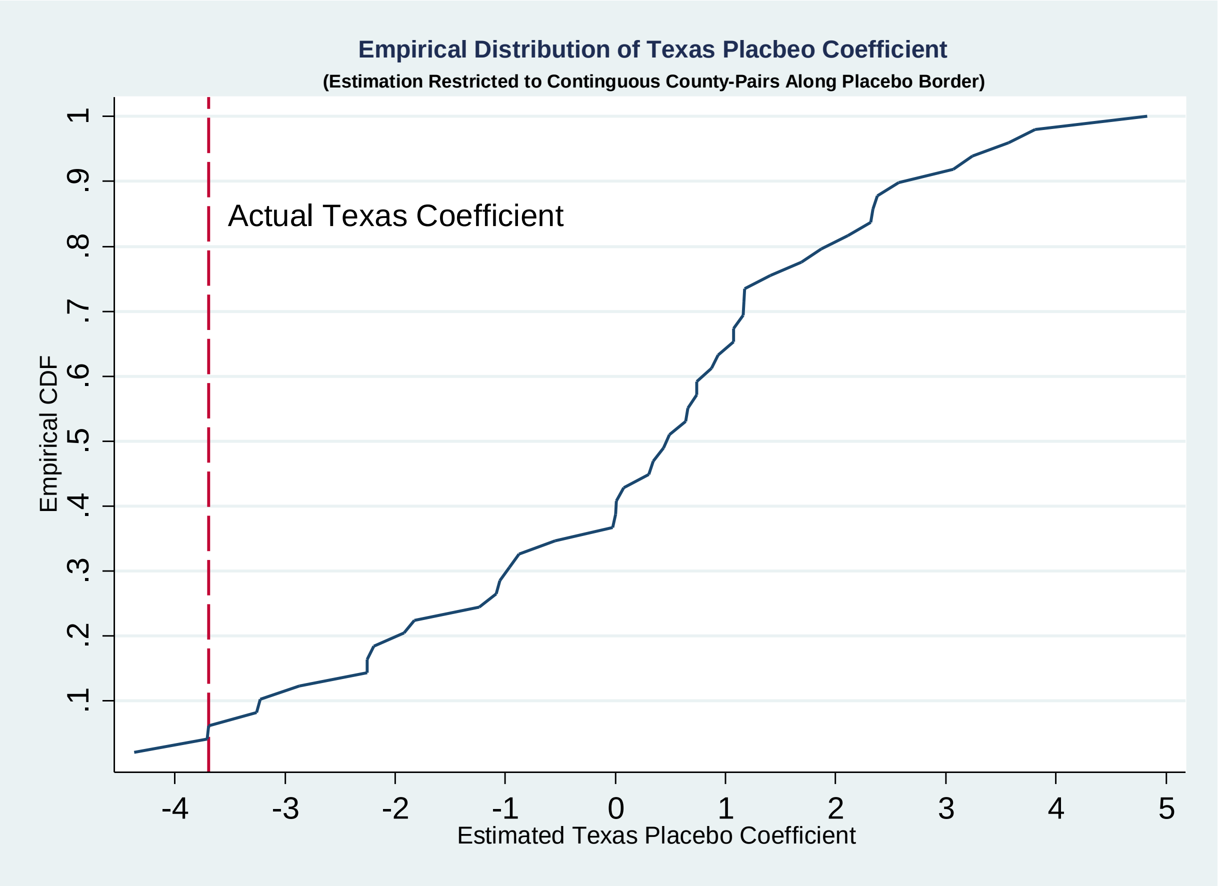
Figure B3 plots the distribution of the estimated discontinuities, for the "covariate index"—discussed on page 13—and the outcome variable, at 100 randomly drawn placebo cutoffs from within the estimation sample, as suggested in Nichols (2007), and shows how they compare with the estimated discontinuity (denoted by the red dashed line) at the actual cutoff—the Texas border.

---

[3] See Chetty, Looney, and Kroft (2009) for a placebo test that is similar in spirit.

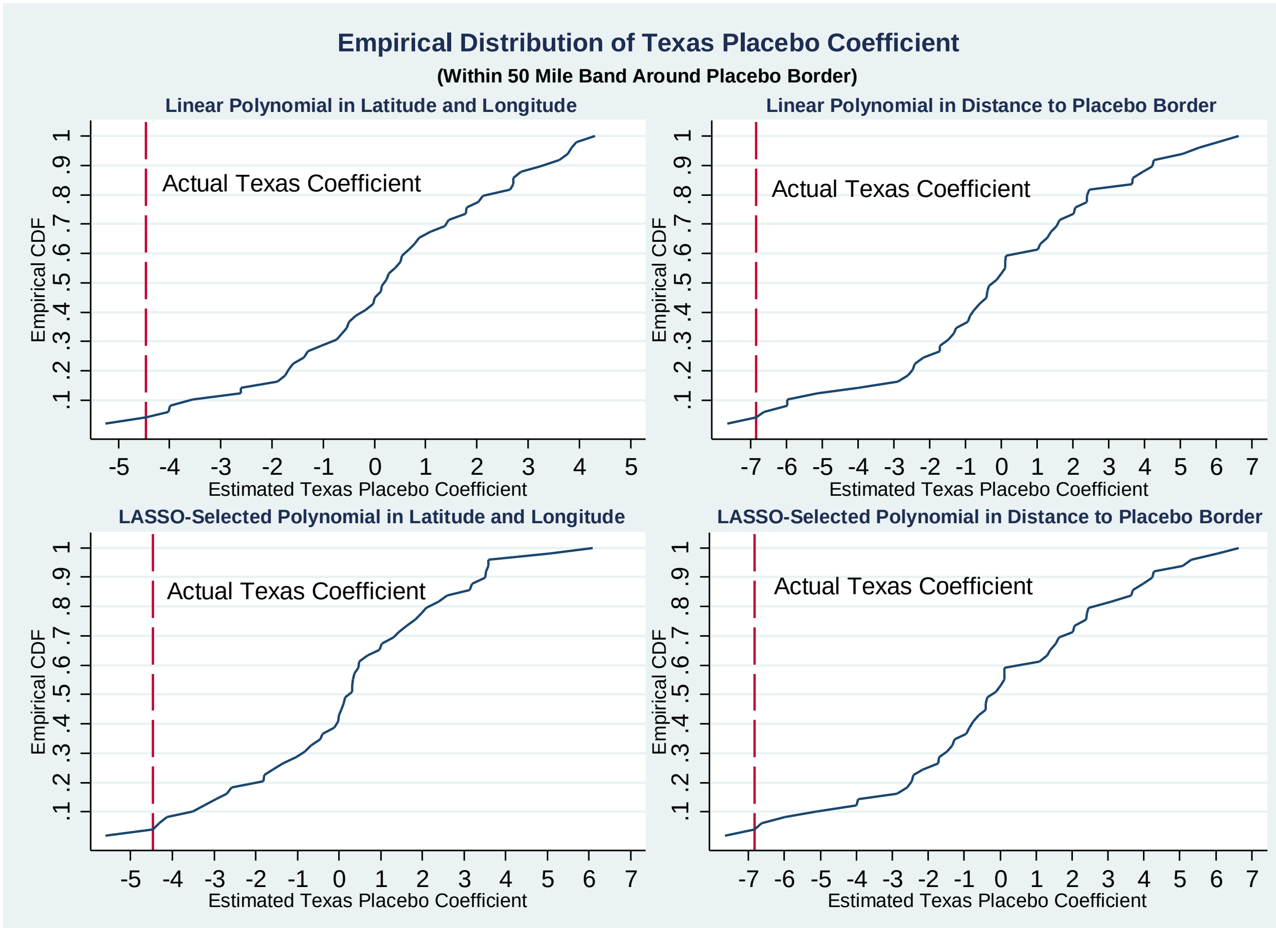
[4] A more parsimonious set than those used in Tables 4 and A5 is used due to lack of data on mortgage characteristics for all states.

Figure B1



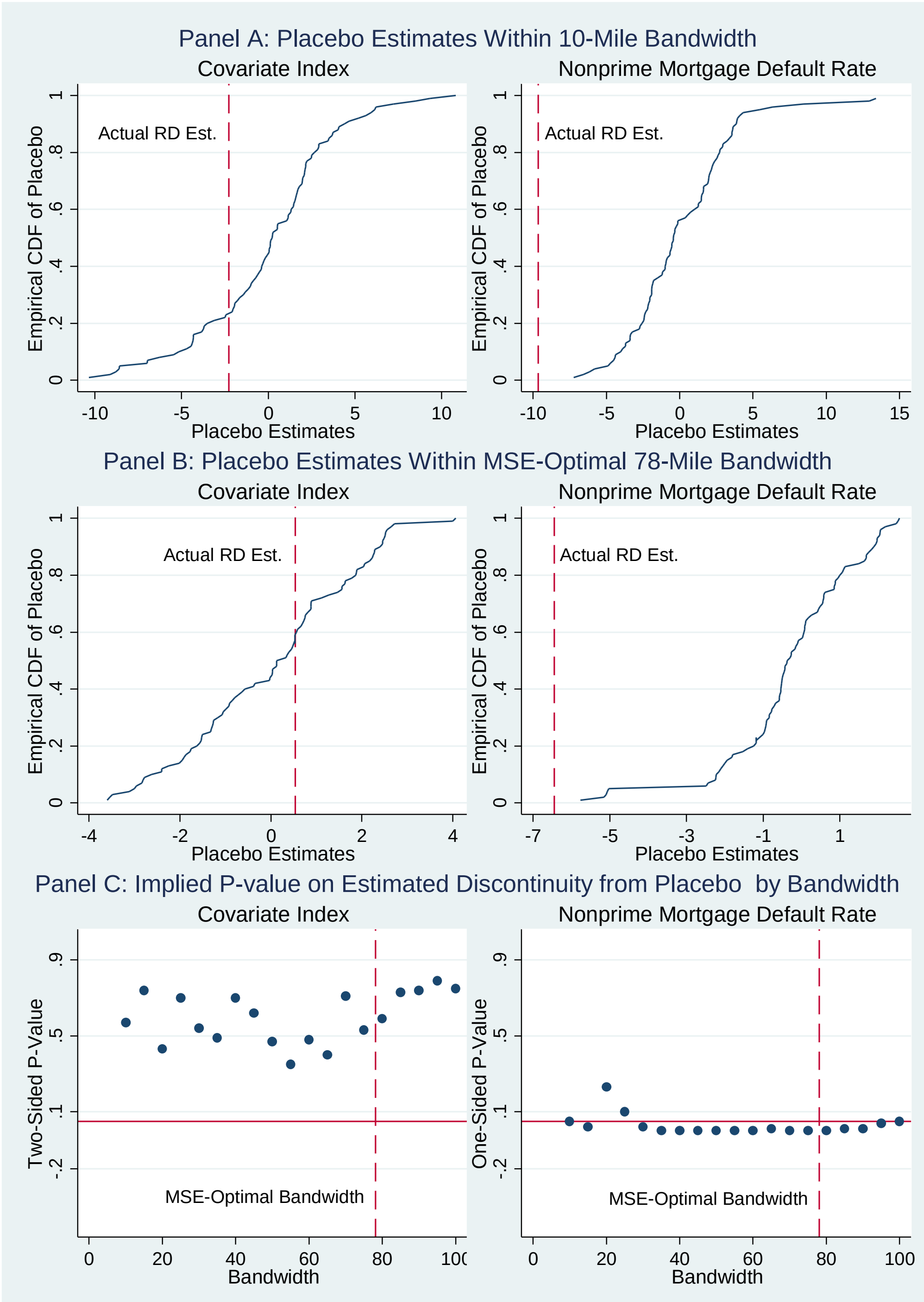
The figure shows the empirical CDF of the 48 placebo estimates using contiguous border county pairs around the borders of the 48 contiguous states. Placebo estimates based on a simple regression of nonprime mortgage default rate on the placebo state dummy and a parsimonious set of key county-level covariates: the unemployment rate, $Lagged\Delta HPI$, initial FICO score, county-pair effects, and year effects. The Texas coefficient is plotted in the chart as a dashed vertical line. The empirical CDF of the Texas coefficient can be interpreted as the p-value for the null hypothesis that the coefficient is zero.

Figure B2



The figure shows the empirical CDF of the 48 placebo estimates using RD estimation based on all counties within 50 miles around the borders of the 48 contiguous states. Placebo estimates are based on a simple regression of nonprime mortgage default rate on the placebo state dummy, the RD polynomial and a parsimonious set of key county-level covariates: the unemployment rate, LaggedΔHPI, initial FICO score, and year effects. The Texas coefficient is plotted in the chart as a dashed vertical line. The empirical CDF of the Texas coefficient can be interpreted as the p-value for the null hypothesis that the coefficient is zero.

Figure B3



Panel A and B plot the distribution of the estimated discontinuities at 100 randomly drawn placebo cutoffs within the estimation sample and shows how they compare with the estimated discontinuity (denoted by the red dashed line) at the actual cutoff—the Texas border. The implied p-value is calculated as the share of placebo estimates that are at least as extreme as the actual estimate. Panel C presents implied p-values from analogous placebo distributions for bandwidths from 10 miles to 100 miles. A two-sided p-value is reported for the covariate index and a one-sided p-value for the outcome variable. The dashed red vertical line in Panel C denotes the MSE-optimal bandwidth and solid red line denotes the p-value of 0.05.

Appendix C: LASSO Specifications

To minimize bias from potentially omitting terms in the RD polynomial, the first two steps of the post-double-LASSO treatment effect estimator consist of using LASSO to select terms in $\sum_{p=0}^{P} \sum_{q=0}^{Q} \delta_{pq} X_{cs}^{p} Y_{cs}^{q}$ that are sufficiently correlated with the outcome variable mortgage default and the Texas treatment dummy ($Texas_s$), respectively. The union of the two sets of terms then replaces the RD polynomial in estimation of (2) and (4) in the third step. More specifically, let $\tilde{y}$ represent the residuals after partialling out all covariates from the dependent variable and the treatment dummy. LASSO uses the following penalized least squares to select the number of terms in the RD polynomial strongly correlated with each of the two variables:[5]

$$\left(\tilde{y}_{icst} - \sum_{p=0}^{P} \sum_{q=0}^{Q} \delta_{pq} X_{cs}^{p} Y_{cs}^{q}\right)^{2} + \frac{\lambda}{n} \sum_{p=0}^{P} \sum_{q=0}^{Q} \left|\delta_{pq}\right| \psi_{pq} \tag{1}$$

LASSO minimizes least square errors subject to a constraint on the sum of absolute value of coefficients. In equation (5), λ is a penalty level determining the parsimony or the number of nonzero coefficients in the model and $\psi_{pq}$are penalty loadings. A high λ selects parsimonious models by setting weakly correlated terms to zero, while a small λ yields models with large number of terms. Note that $\lambda = 0$ yields the OLS specification. I select both λ based on practical guidelines and procedures by Belloni et al. (2014a) who suggest that a particularly good choice is:

$$\hat{\lambda} = 2.2\sqrt{n}\Phi(1 - (.1/\log(\max(k, n)))\ \ /(2k)), \tag{2}$$

where k is the number of number of terms in the RD polynomial, n the number of observations, and $\Phi(.)$ is the standard normal CDF. I also explore the sensitivity of estimates to different choices of λ.

Tables C1-C3 examine the sensitivity of post-double-LASSO estimates to different LASSO penalty levels $\hat{\lambda}$. The top panel repeats estimates using $\hat{\lambda}$ from Table 3 that was based on equation (6). The middle panel sets the penalty level to half of $\hat{\lambda}$. The number of terms selected in the multidimensional RD increases slightly for some distance bands, as expected, but estimates remain largely identical. The bottom panel further reduces the penalty level to just 1/5th of $\hat{\lambda}$ and shows that although a larger number of terms is selected as the penalty level is lowered, estimated

[5] (Belloni et al., 2014a) show that other baseline covariates can be straightforwardly included in the final step of the post-double-LASSO treatment effect estimator by partialling them out from the outcome variable and each of the set of regressors on which LASSO selection is being used, before embarking on the first two steps.

impacts are highly robust to changes in LASSO penalty levels. Overall, Table B1 shows that multidimensional RD estimates are not particularly sensitive to chosen penalty levels.

Table C2 is isomorphic to Table C1 and shows that multidimensional RD estimates for nonprime mortgages using post-double-LASSO to select number of terms in the RD polynomial are remarkably robust to different LASSO penalty levels $\hat{\lambda}$. Post-double-LASSO estimates with one-dimensional RD polynomial yielded results similar to baseline linear specifications presented in the bottom panel of Table 2 and are not presented due to space constraints. Finally, Table C3 shows that the post-double-LASSO estimates presented in Table A4 are robust to different LASSO penalty levels $\hat{\lambda}$.

Table C1: Robustness of Multidimensional RD with Post-Double-LASSO to LASSO Penalty
(***Dependent Variable: County-Level Default Rate)***
(Data: LPS Data on All Mortgages Grouped to County Level)

	(1)	(2)	(3)	(4)	(5)
Distance Band at Texas Border	<25 miles	<50 miles	<75 miles	<100 miles	All
LASSO $\hat{\lambda} = 2.2\sqrt{n}\Phi(1-(.1/\log(\max(k,n)))\ /(2k))$ §					
Texas	-1.678**	-1.463**	-0.804*	-0.591*	-0.700**
	(0.447)	(0.413)	(0.429)	(0.321)	(0.207)
LASSO Selected Polynomial Terms	*X*	*X*	*None*	*X,Y, XY*	*X,Y, XY*
LASSO $\lambda = \hat{\lambda}/2$ §					
Texas	-1.532**	-1.401**	-1.099**	-0.617**	-0.687**
	(0.357)	(0.379)	(0.394)	(0.313)	(0.251)
LASSO Selected Polynomial Terms	X,Y	X,Y	X,Y,XY	X,Y,XY, XY^3	X,Y,XY, X^2Y
LASSO $\lambda = \hat{\lambda}/5$ §					
Texas	-1.377**	-1.576**	-1.499**	-0.986**	-0.687**
	(0.290)	(0.373)	(0.322)	(0.312)	(0.251)
LASSO Selected Polynomial Terms	X,Y,X^2, XY^2	X,Y,XY, Y^4,XY^3	X,Y,XY, Y^4,XY^3	X,Y,XY, Y^4,XY^3	X,Y,XY, X^2Y
Observations	310	568	828	1072	2250
Counties	64	116	169	218	456
R-Square	0.8765	0.8747	0.8993	0.8853	0.8288
Other Covariates	Yes	Yes	Yes	Yes	Yes
Year Effects	Yes	Yes	Yes	Yes	Yes
Border FE	Yes	Yes	Yes	Yes	Yes

*Significant at 10% level; **Significant at 5% level. Robust standard errors clustered by county in parenthesis. The dependent variable mortgage default is defined as share of mortgages 90-plus days delinquent or in foreclosure or REO. Results presented are from linear regression of county-year level mortgage default rates from 2007 to 2011 on the Texas dummy and multidimensional RD polynomial in latitude and longitude. Other county-level baseline covariates included are the county unemployment rate, 1-year lagged log house price change (LaggedΔHPI), county-level initial FICO score, share of mortgages with initial LTV 80 percent or higher, county-level log median household income, share of adjustable rate mortgages, share of cash-out refinance mortgages, and average county-level mortgage denial rate between 2000 and 2006, year effects, and state border-segment fixed effects. Estimates weighted by number of loans in each county-year cell. The coefficient on the Texas dummy should be interpreted as the discontinuity in mortgage default rate on Texas side of the border vis-a-vis NM, OK, AR, and LA side of the border. Data from (Holmes, 1998) was used to get distances of county centroid to the Texas border with respective states. Data on county-level nonprime default rates and other mortgage characteristics are from the LPS database on all residential mortgages. §LASSO penalty level λ chosen using guidelines in Belloni et al. (2014a); see equation (6).

Table C2: Robustness of Multidimensional RD with Post-Double-LASSO to LASSO Penalty
(***Dependent Variable: County-Level Default Rate)***
(Data: ABS Data on Nonprime Mortgages Grouped to County Level)

	(1)	(2)	(3)	(4)	(5)
Distance Band at Texas Border	<25 miles	<50 miles	<75 miles	<100 miles	All
LASSO $\hat{\lambda} = 2.2\sqrt{n}\Phi(1-(.1/\log(\max(k,n)))\ /(2k))$ §					
Texas	-3.581**	-4.019**	-3.609**	-2.128**	-2.905**
	(1.352)	(0.896)	(1.002)	(0.846)	(0.746)
LASSO Selected Polynomial Terms	Y,Y^2	*None*	X,Y^2	X	X,Y,XY
LASSO $\lambda = \hat{\lambda}/2$ §					
Texas	-3.581**	-3.810**	-3.232**	-1.905**	-2.905**
	(1.352)	(0.830)	(0.939)	(0.896)	(0.746)
LASSO Selected Polynomial Terms	Y,Y^2	X	X,Y,Y^2	$X,Y,$ $Y,$ Y^3	$X,Y,XY,$
LASSO $\lambda = \hat{\lambda}/5$ §					
Texas	-4.420**	-4.072**	-3.629**	-2.117**	-2.905**
	(1.188)	(0.859)	(0.921)	(0.851)	(0.746)
LASSO Selected Polynomial Terms	X,Y^2,XY^3	X,Y^3,X^2Y^2	$X,Y,Y^2,$ XY	$X,Y,$ Y^3	$X,Y,XY,$
Observations	310	569	829	1073	2252
Counties	64	117	170	219	457
R-Square	0.8977	0.8888	0.8985	0.9115	0.8733
Other Covariates	Yes	Yes	Yes	Yes	Yes
Year Effects	Yes	Yes	Yes	Yes	Yes
Border FE	Yes	Yes	Yes	Yes	Yes

*Significant at 10% level; **Significant at 5% level. Robust standard errors clustered by county in parenthesis. The dependent variable mortgage default is defined as share of mortgages 90 day+ delinquent or in foreclosure or REO. Results presented are from linear regression of county-year level mortgage default rates from 2007 to 2011 on the Texas dummy and multidimensional RD polynomial in latitude and longitude. Other county-level baseline covariates included are the county unemployment rate, 1-year lagged log house price change (LaggedΔHPI), county-level initial FICO score, share of mortgages with initial CLTV 80 percent or higher, county-level log median household income, share of adjustable rate mortgages, share of cash-out refinance mortgages, and average county-level mortgage denial rate between 2000 and 2006, year effects, and state border-segment fixed effects. Estimates weighted by number of loans in each county-year cell. The coefficient on the Texas dummy should be interpreted as the discontinuity in mortgage default rate on Texas side of the border vis-a-vis NM, OK, AR, and LA side of the border. Data from (Holmes, 1998) was used to get distances of county centroid to the Texas border with respective states. Data on county-level nonprime default rates and other mortgage characteristics are from ABS database on nonprime mortgages. §LASSO penalty level λ chosen using guidelines in (Belloni et al., 2014a); see equation (6).

Table C3: Robustness to Inclusion of State-Level Policy Variables using Multidimensional RD with Post-Double-LASSO

(***Dependent Variable: County-Level Default Rate)***

(Data: ABS Data on Nonprime Mortgages Grouped to County Level)

	(1)	(2)	(3)	(4)	(5)
Distance Band at Texas Border	<25 miles	<50 miles	<75 miles	<100 miles	All
LASSO $\hat{\lambda} = 2.2\sqrt{n}\Phi(1 - (.1/\log(\max(k,n)))\ /(2k))$ §					
Texas	-6.465**	-4.806**	-3.878**	-2.476*	-3.087**
	(2.003)	(1.499)	(1.593)	(1.331)	(1.249)
LASSO Selected Polynomial Terms	*None*	*None*	*None*	*None*	*X,Y*
LASSO $\lambda = \hat{\lambda}/2$ §					
Texas	-6.465**	-4.806**	-3.486**	-3.308**	-3.288**
	(2.003)	(1.499)	(1.743)	(1.332)	(1.300)
LASSO Selected Polynomial Terms	*None*	*None*	X,Y^2	X,X^2	X,Y,X^2
LASSO $\lambda = \hat{\lambda}/5$ §					
Texas	-6.986**	-5.282**	-3.322*	-2.986**	-4.556**
	(2.081)	(1.639)	(1.692)	(1.384)	(1.516)
LASSO Selected Polynomial Terms	X	X,X^2,XY,Y^4	X,Y,X^2,Y^2,Y^4	X,Y,X^2,Y^2,Y^4	X,Y,X^2,Y^2,XY,X^2Y
Observations	310	569	829	1073	2252
Counties	64	117	170	219	457
R-Square	0.9042	0.8980	0.9074	0.9160	0.8751
Other Covariates	Yes	Yes	Yes	Yes	Yes
State Policy Vars	Yes	Yes	Yes	Yes	Yes
Year Effects	Yes	Yes	Yes	Yes	Yes
Border FE	Yes	Yes	Yes	Yes	Yes

*Significant at 10% level; **Significant at 5% level. Robust standard errors clustered by county in parenthesis. The dependent variable mortgage default is defined as share of mortgages 90 day+ delinquent or in foreclosure or REO. Results presented are from linear regression of county-year level mortgage default rates from 2007 to 2011 on the Texas dummy and multidimensional RD polynomial in latitude and longitude. Other county-level baseline covariates included are the county unemployment rate, 1-year lagged log house price change (LaggedΔHPI), county-level initial FICO score, share of mortgages with initial CLTV 80 percent or higher, county-level log median household income, share of adjustable rate mortgages, share of cash-out refinance mortgages, average county-level mortgage denial rate between 2000 and 2006, year effects, and state border-segment fixed effects. Estimates are weighted by number of loans in each county-year cell. The coefficient on the Texas dummy should be interpreted as the discontinuity in mortgage default rate on Texas side of the border vis-a-vis NM, OK, AR, and LA side of the border. Data from (Holmes, 1998) was used to get distances of county centroid to the Texas border with respective states. Data on county-level nonprime default rates and other mortgage characteristics are from ABS database on nonprime mortgages. State-specific policy variables included are dummies for judicial foreclosure, whether the state allows redemption, and state-level house price elasticity. §LASSO penalty level λ chosen using guidelines in Belloni et al. (2014a); see equation (6).