Online Appendix

Labor Market Effects of Credit Constraints: Evidence from a Natural Experiment

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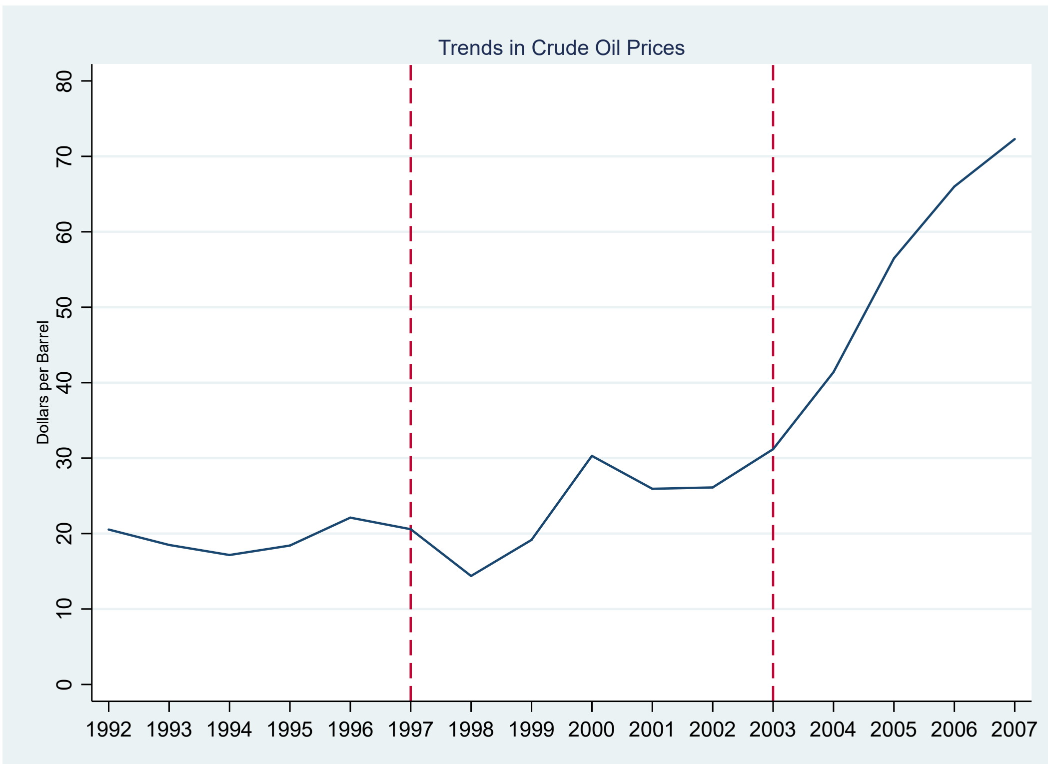
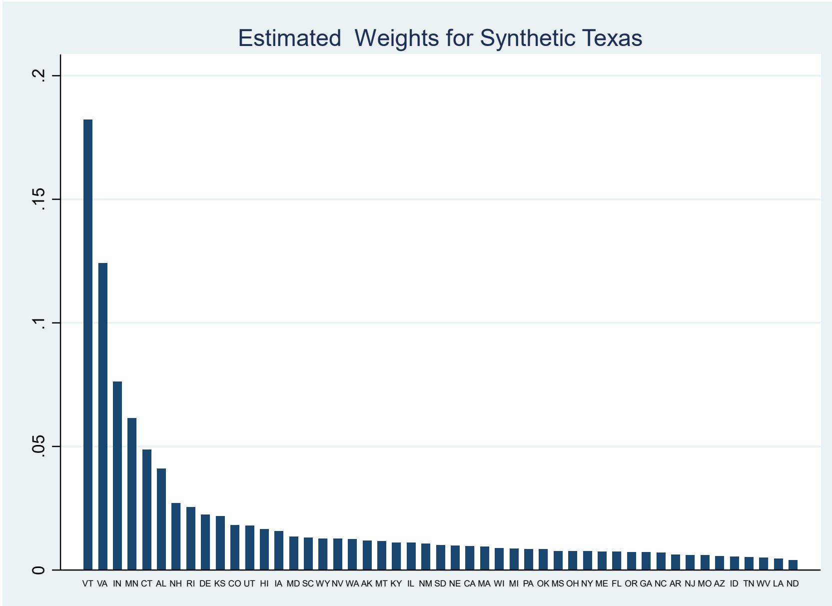
Appendix A: Additional Figures and Tables

Figure A1



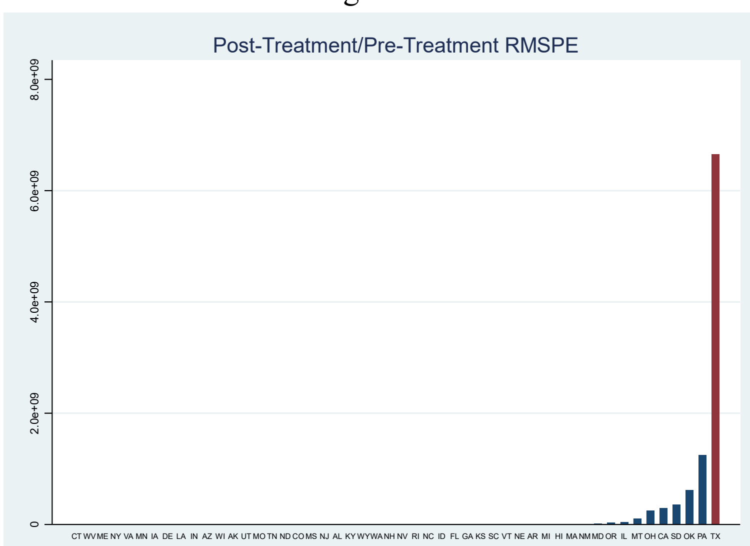
Sources: Department of Energy; Haver Analytics.

Figure A2



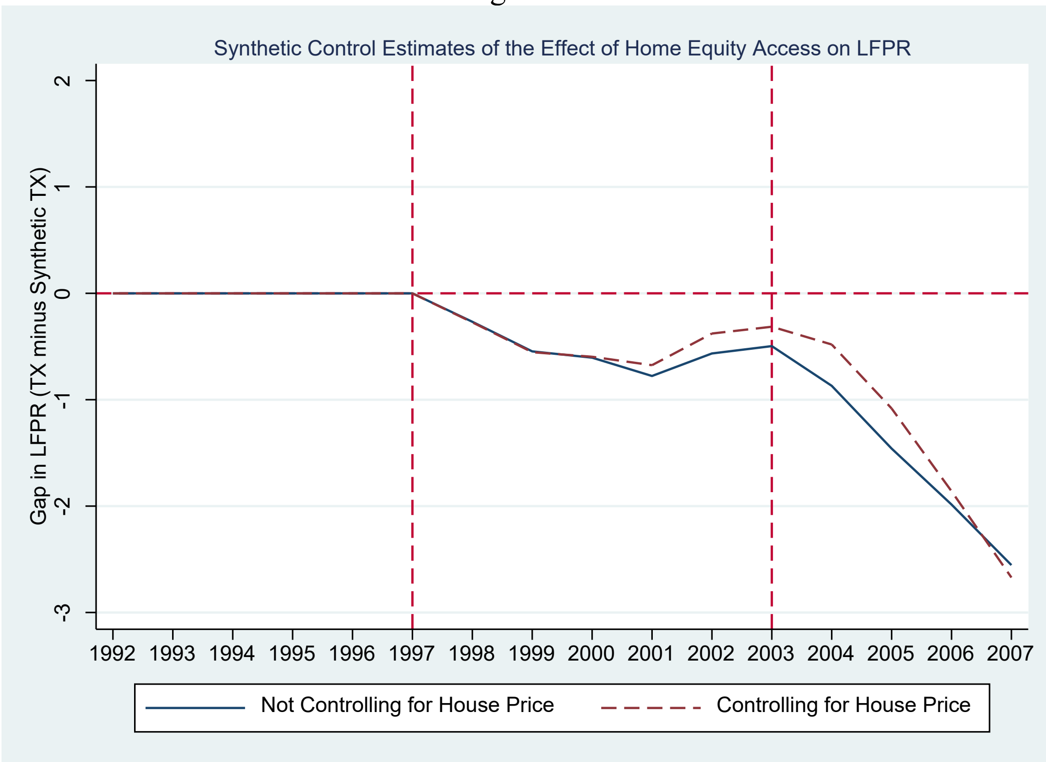
Notes: The figure shows the estimated weights for different states in constructing synthetic Texas for the SCM-ADH estimates plotted in Figure 2A/2B and reported in column (1) of Table 5. See notes to Figure 2A/2B and Table 5 for more details. All analysis using synthetic control estimation is carried out using “Synth” package and “Synth Runner” packages (Abadie at al. 2014; Galiani and Quistorff, 2017). Sources: BLS/LAUS; Authors’ calculations.

Figure A3



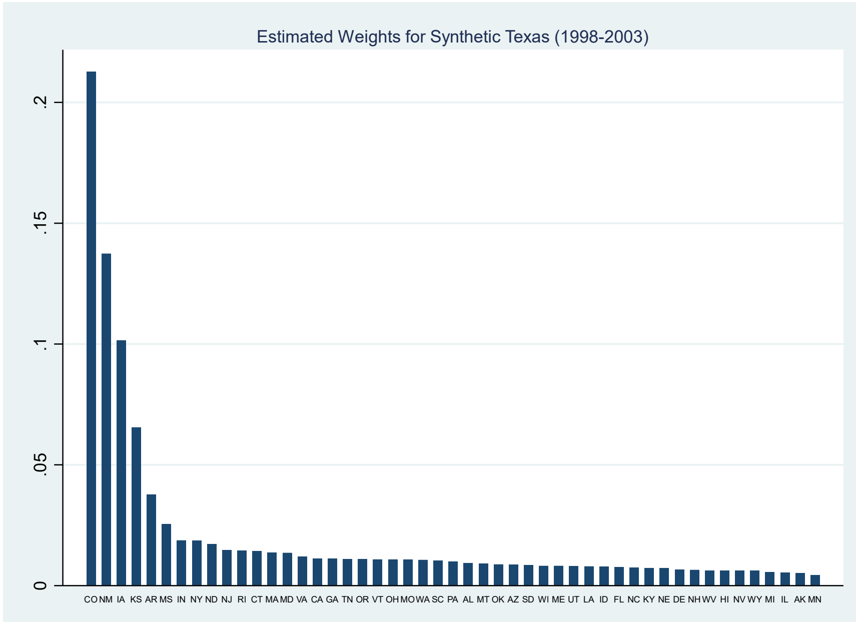
Notes: The figure plots the ratio of post-treatment RMSPE to the pre-treatment RMSPE of Texas and other control states for the SCM-ADH estimates plotted in Figure 2A/2B and reported in column (1) of Table 5. RMSPE for each state is simply the square root of the mean squared difference between the LFPR of that state and the synthetic control for that state. The optimal weights for Texas are shown in Figure A2. The figure shows that the post-treatment difference in LFPR of Texas and synthetic Texas relative to the pre-treatment difference is the largest of all states. Sources: BLS/LAUS; Authors’ calculations.

Figure A4



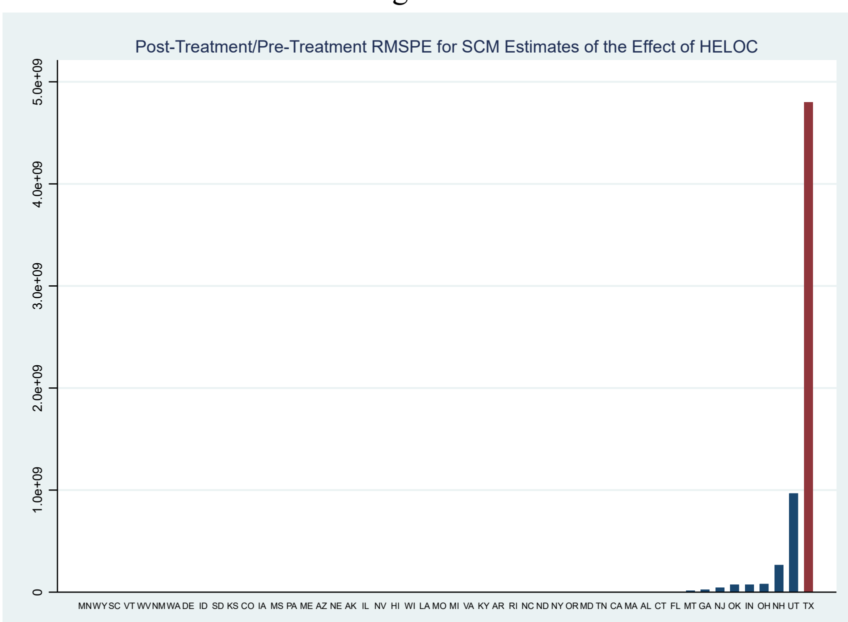
Notes: The figure plots the difference between LFPR paths of Texas and synthetic Texas using the SCM-ADH specification with all pre-treatment lags of LFPR to construct synthetic Texas. Vertical dashed lines denote 1997 and 2003, the years of introduction of HEL and HELOC, respectively. The figure shows that the pre-treatment path of LFPR of "synthetic Texas" is almost identical to that for Texas, yet the post-treatment paths diverge significantly. The figure shows that synthetic control estimates based on LFPR with house price partialled out (dashed line) yield somewhat smaller labor supply reduction than the baseline specification without adjustment for house prices (solid line). Estimation carried out using "Synth" package and "Synth Runner" packages (Abadie at al. 2014; Galiani and Quistorff, 2017). Data Sources: BLS/LAUS; Haver Analytics; Basic CPS-IPUMS; Authors' calculations.

Figure A5



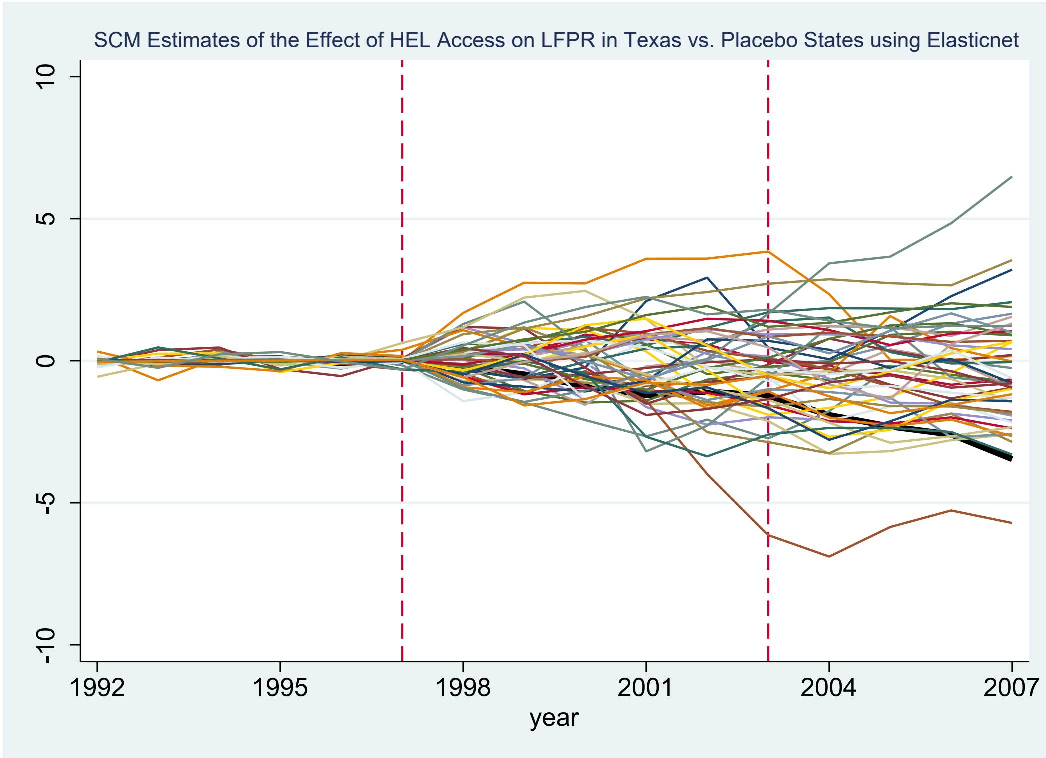
Notes: The figure shows the estimated weights for different states in constructing synthetic Texas for the SCM-ADH estimates plotted in Figure 4A/4B. The figure is analogous to Figure A2, except that it plots estimated weights for SCM-ADH estimated effects of HELOC in the post-2003 period. See notes to Figure A2 for more details.

Figure A6



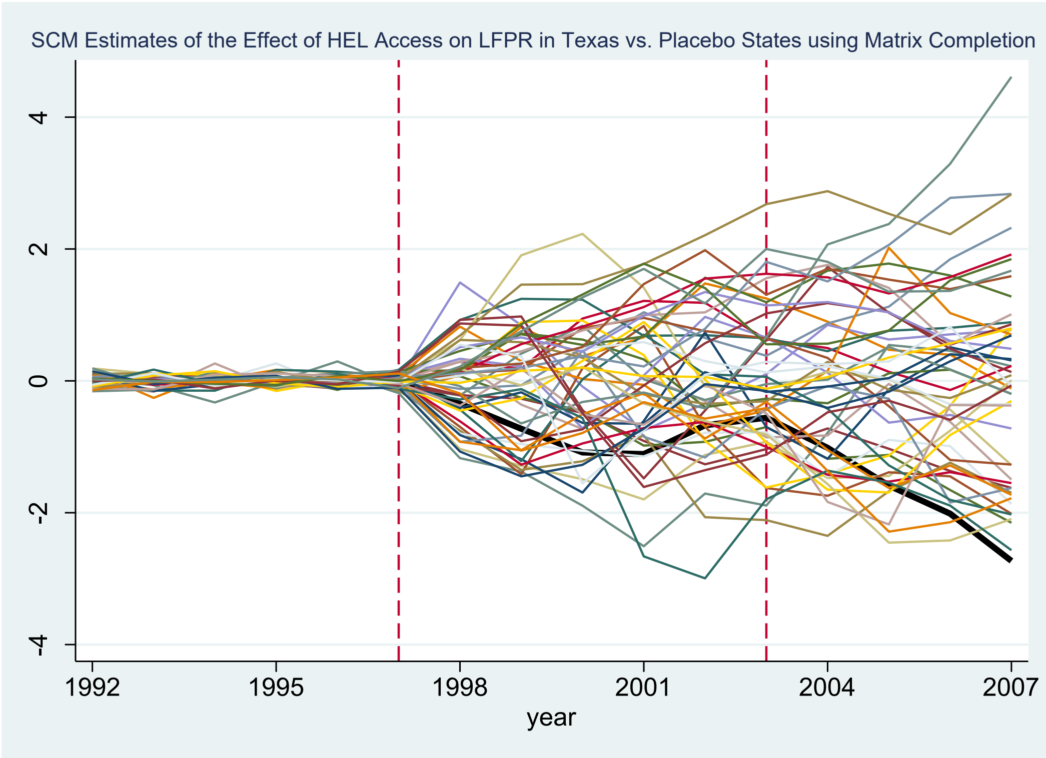
Notes: The figure plots the ratio of post-HELOC (2004-2007) RMSPE to the pre-HELOC (1998-2003) RMSPE of Texas vs. other states for the synthetic control estimates plotted in Figure 4A/4B. The figure is analogous to Figure A3, except that it uses SCM-ADH estimates of HELOC in the post-2003 period. See notes to Figure A3 for more details.

Figure A7



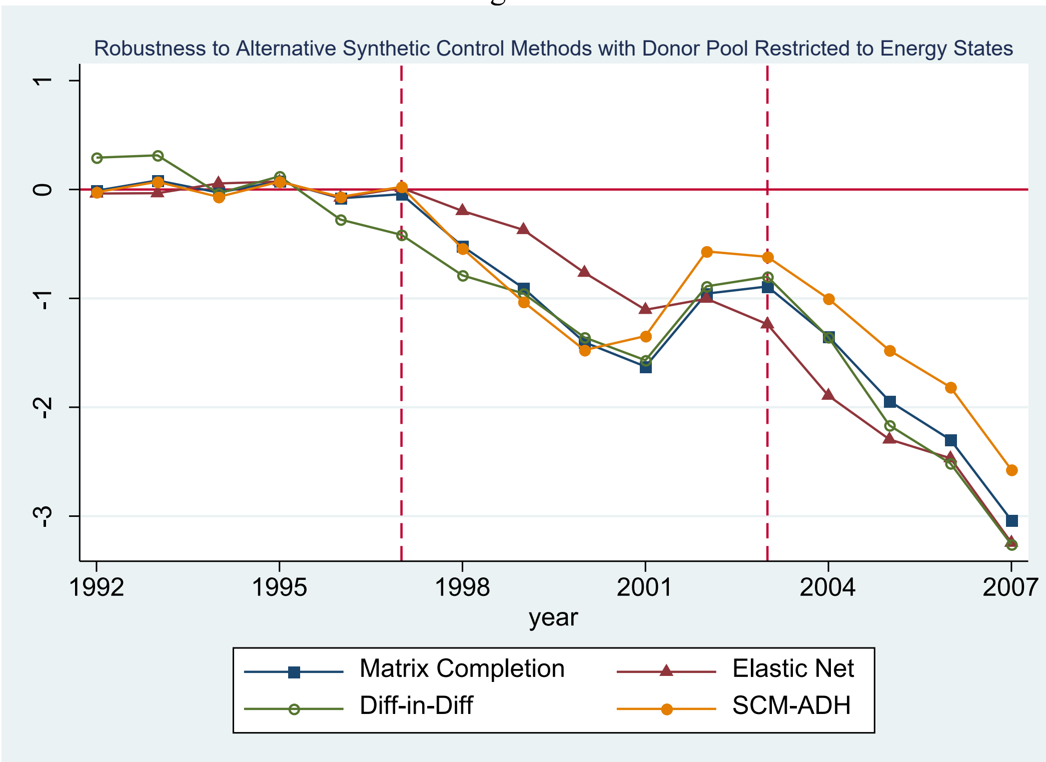
Notes: The figure plots the difference between LFPR paths of each state and its synthetic control for the SCM-Elastic Net model, with the difference between Texas and synthetic Texas presented in solid bold. The figure shows that just a handful of placebo states have post-treatment LFPR relative to their synthetic counterparts as negative as Texas. Estimation carried out using software code for DID/SCM-ADH/SCM-Elastic Net/MC-NNM available from https://github.com/susanathey/MCPanel. Data Sources: BLS/LAUS; Haver Analytics; Basic CPS-IPUMS; Authors' calculations. Data Sources: BLS/LAUS; Haver Analytics; Basic CPS-IPUMS; Authors' calculations.

Figure A8



Notes: The figure plots the difference between LFPR paths of each state and its synthetic control for the Matrix Completion (MC-NNM) model, with the difference between Texas and synthetic Texas presented in solid bold. The figure shows that just a handful of placebo states have post-treatment LFPR relative to their synthetic counterparts as negative as Texas. Estimation carried out using software code for DID/SCM-ADH/SCM-Elastic Net/MC-NNM available from https://github.com/susanathey/MCPanel. Data Sources: BLS/LAUS; Haver Analytics; Basic CPS-IPUMS; Authors' calculations. Data Sources: BLS/LAUS; Haver Analytics; Basic CPS-IPUMS; Authors' calculations.

Figure A9



Notes: The figure plots the pre-HEL (1992-1997) and post-HEL (1998-2007) difference between LFPR paths for Texas and synthetic Texas using different synthetic control methods and the specification with all pre-treatment lags of LFPR to construct synthetic Texas, with the donor pool restricted to energy states. Vertical dashed lines denote 1997 and 2003, the years of introduction of HEL and HELOC, respectively. The figure shows that the pre-treatment path of LFPR of Texas is mostly identical to that for synthetic Texas for all synthetic control methods (but not for DID), yet the post-treatment paths diverge significantly. Estimation carried out using software code for DID/SCM-ADH/SCM-Elastic Net/MC-NNM available from https://github.com/susanathey/MCPanel. Data Sources: BLS/LAUS; Haver Analytics; Basic CPS-IPUMS; Authors' calculations.

Table A1: Difference-in-Differences Estimates using only Border Counties

	(1)	(2)	(3)
Texas X 1998-2003	-1.798	-1.117	-2.149
	(1.084)	(0.352)	(1.336)
Texas X Post 2003	-3.699	-2.44	-3.16
	(2.002)	(0.413)	(2.568)
County Fixed Effects	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	No
State X Linear Trend	No	Yes	No
County-Pair X Year Effects	No	No	Yes
Observations	2128	2128	2128
Adj R-Sq	0.6091	0.6397	0.6552

Notes: Robust standard errors clustered by county are reported in parenthesis. Estimation is weighted by county population. Using county-level data from 1992-2007, the table reports DID coefficients from a regression of county-level LFPR on the interactions between the treatment dummy (an indicator for Texas) and dummies for 1998-2003 and 2003-2007, controlling various fixed effects as indicated. Estimation sample restricted to contiguous counties around Texas' border with other states. Sources: BLS-LAUS; Authors' calculations.

Table A2: Estimated Effects of Home Equity Access on LFP by Homeowners and Renters using Panel Data Specifications with Individual Fixed Effects

	(1)	(2)	(3)
Panel A: Full Sample			
	All	Homeowners	Renters
Texas X 1998-2003	-1.561	-2.813	0.660
	(0.471)	(0.539)	(0.704)
Texas X Post 2003	-1.243	-2.316	1.279
	(0.595)	(0.742)	(0.809)
Year Fixed Effects	Yes	Yes	Yes
Demographic Controls	Yes	Yes	Yes
Bank Branching Control	Yes	Yes	Yes
Observations	159087	104931	54156
Adj R-Sq	0.714	0.718	0.731
Panel B: Texas Sample			
	(1)	(2)	(3)
	All	Homeowners	Renters
1998-2003	-3.058	-2.363	-1.521
	(1.479)	(1.923)	(2.465)
Post 2003	-3.899	-2.344	-1.492
	(2.286)	(2.976)	(3.793)
Demographic Controls	Yes	Yes	Yes
Bank Branching Control	Yes	Yes	Yes
Observations	9131	5589	3542
Adj R-Sq	0.729	0.734	0.749

Notes: Robust standard errors clustered by state are reported in parenthesis in Panel A and robust standard errors in Panel B. The table presents unweighted estimates from a DID regression of labor force participation dummy (LFP) with individual fixed effects. Other demographic covariates included in columns (1) and (2) are: age, married, dummies for high school diploma, and college degree. Results are based on the entire unbalanced panel from 1992 to 2007 in the PSID. Sources: PSID-CNEF; Authors' calculations.

Appendix B: Theoretical Framework

We extend the standard two-period life-cycle model of Rossi and Trucchi (2016) to a three-period set-up and, following Hurst and Stafford (2004) and Bhutta and Keys (2016), explicitly incorporate home ownership, mortgage borrowing, house price appreciation, home equity extraction, and collateral constraints to capture the key features of the Texas housing market. In our model, the agent chooses consumption (c_t) in the three periods $(t = 1,2,3)$, and leisure (l_t), and home equity extraction (E_t) in the first two periods to maximize a three-period intertemporally separable utility function with δ the discount factor:

$$U = u(c_1, l_1) + \delta u(c_2, l_2) + \delta^2 U(c_3, 1)$$

subject to the budget constraints:

$$c_1 = w(1 - l_1) + E_1 - r\pi H_0 - A_1$$

$$c_2 = A_1(1 + r) + w(1 - l_2) + E_2 - (1 + r)E_1 - r\pi H_0 - A_2$$

$$c_3 = P + A_2(1 + r) + [(1 + r_H)^3 H_0 - (1 + r)\pi H_0] - E_2(1 + r)$$

and the collateral constraints:

$$E_1 \leq a(1 + r_H)H_0 - \pi H_0$$

$$E_2 \leq a(1 + r_H)^2 H_0 - \pi H_0$$

To keep the model simple we normalize total time endowment to 1, so that labor supply in the first two periods are $(1 - l_t)$ at wage rate (w), and assume that the agent retires with retirement income P in the third period. Following Hurst and Stafford (2004), at the beginning of the first period, the agent owns a home worth H_0 with an initial LTV (π) financed with an interest-only mortgage that equals πH_0, with a fixed mortgage rate (r). The interest-only mortgage payment each period is πH_0, and the constant rate of house price appreciation is r_H. The agent chooses to extract equity E_t subject to the collateral constraint that total equity extraction *plus* the outstanding mortgage amount cannot exceed some fraction (a) of the current home value. Furthermore, as per Texas law an existing home equity loan must be paid off before another one is taken. The parameter a governs the ease of credit access. It equaled 1 in all other states throughout the sample period from 1992 to 2007—households could borrow the entire home equity—but switched from 0 to 0.8 in Texas after the 1997 amendment. A_1 and A_2 represent savings in the first two periods, respectively. The agent leaves no bequests in period 3 and consumes the proceeds from home sale, $(1+r_h)^3 H_0$, after paying off the interest only mortgage (πH_0) and borrowed equity $E_2(1+r)$. For the three-period model the Lagrangian can be written as is:

$$\max_{\{c_1,l_1,c_2,l_2,c_3,E_1,E_2.\mu_1,\mu_2,\mu_3\}} \quad L = u(c_1,l_1) + \delta u(c_2,l_2) + \delta u(c_3,1)$$

$$-\mu_1[c_1 - w(1-l_1) - E_1 + r\pi H_0 + A_1]$$

$$-\mu_2[c_2 - (1+r)A_1 - w(1-l_2) - E_2 + (1+r)E_1 + r\pi H_0 + A_2]$$

$$-\mu_3[c_3 - (1+r)A_2 - P - (1+r_H)^3 H_0 + (1+r)\pi H_0 + (1+r)E_2]$$

$$-\mu_4[E_1 - a(1+r_H)H_0 + \pi H_0]$$

$$-\mu_5[E_2 - a(1+r_H)^2 H_0 + \pi H_0]$$

μ_1, μ_2, μ_3, μ_4, and μ_5 are Kuhn-Tucker multipliers.

The first-order and complementary slackness conditions are:

$$u_{c_1} - \mu_1 = 0,$$

$$u_{l_1} - \mu_1 w = 0,$$

$$\delta u_{c_2} - \mu_2 = 0,$$

$$\delta u_{l_2} - \mu_2 w = 0,$$

$$\delta^2 u_{c_3} - \mu_3 = 0,$$

$$\mu_1 - (1+r)\mu_2 - \mu_4 = 0,$$

$$\mu_2 - (1+r)\mu_3 - \mu_5 = 0,$$

$$\mu_4[E_1 - a(1+r_H)H_0 + \pi H_0] = 0,$$

$$E_1 \leq a(1+r_H)H_0 - \pi H_0,$$

$$\mu_4 \geq 0,$$

$$\mu_5[E_2 - a(1+r_H)^2 H_0 + \pi H_0] = 0,$$

$$E_2 \leq a(1+r_H)^2 H_0 - \pi H_0,$$

$$\mu_5 \geq 0.$$

These first order conditions (FOCs) imply that, the optimum is characterized by equal marginal utility of consumption and labor within as well as between periods. The FOCs also imply that the following hold:

$$u_{c_1} = u_{l_1}/w = (1+r)\delta u_{c_2} + \mu_4 = (1+r)\delta u_{l_2}/w + \mu_4 \tag{A1}$$

$$\delta u_{c_2} = \delta u_{l_2}/w = (1+r)\delta^2 u_{c_3} + \mu_5, \tag{A2}$$

where, μ_4 and μ_5 are the multipliers on the collateral constraints in period 1 and 2, respectively. Let l_t^C denote period t leisure when the collateral constraints bind ($\mu_4 > 0, \mu_5 > 0$) and l_t^{NC} when they do not bind ($\mu_4 = 0, \mu_5 = 0$). Assuming separability in consumption and leisure and using analysis similar to Rossi and Trucchi (2016), equation (1) implies that $u_{l_1}^C > u_{l_1}^{NC}$and, therefore intuitively, $l_1^C < l_1^{NC}$, i.e., when the collateral constraint binds, leisure is lower and labor supply higher. Unlike period 1, such informal analysis of FOCs reveals no clear relationship between the constraints and labor supply in period 2—(1) suggests that $l_2^C > l_2^{NC}$, (2) implies that $l_2^C < l_2^{NC}$.

For the special case of households facing binding collateral constraints, further insights can be gained by assuming an intertemporally separable log utility function that is also separable in consumption and leisure. In this case, the optimal solutions for leisure in period 1 and 2 are:

$$l_1^* = \frac{w + a(1+r_H)H_0 - (1+r)\pi H_0 - A_1}{2w}$$

$$l_2^* = \frac{w + a(r_H - r)(1 + r_H)H_0 + (1 + r)A_1 - A_2}{2w}$$

Note that l_1^* varies positively with ease of credit access, a, if home value, $(1 + r_H)H_0$, is positive. So as a increases and the collateral constraint becomes less binding, leisure increases and labor supply declines in period 1. However, the relationship between a and l_2^* remains ambiguous, as it depends on the sign of $(r_H - r)$.[1]

Comparative Statics

Now let us do comparative statics of the optimal choice l^* with respect to a using these conditions, i.e., let us derive dl_1^*/da. First, note that a only directly determines the first-period credit constraint on E_1. If the first-period collateral constraint does not bind, $\mu_4 > 0$, $E_1^* < a(1 + r_H)H_0 - \pi H_0$, and $dE_1^*/da = 0$. On the other hand, if the first-period collateral constraint binds, $\mu_4 = 0$, $E_1^* = a(1 + r_H)H_0 - \pi H_0$, and $dE_1^*/da = (1 + r_H)H_0 > 0$. Putting the two cases together, we know that:

$$\frac{dE_1^*}{da} \geq 0.$$

By the chain rule and making use of the previous equation yields the following sign of dl_1^*/da up to weak inequality:

$$sign\left[\frac{dl_1^*}{da}\right] = sign\left[\frac{dl_1^*}{dE_1^*}\frac{dE_1^*}{da}\right] = sign\left[\frac{dl_1^*}{dE_1^*}\right].$$

[1]Although we don't formally model present-biased preferences, it is worth noting that the existence of present-bias also would reinforce the notion that relaxing collateral constraints should lower labor supply in the first period and have ambiguous effects in the second period. Previous research on present-biased preferences has shown that, in a setting without home equity, impatience leads to lower lifetime consumption and labor supply, as well as a shift of future consumption toward the present (Laibson, 1997; Fredrick, Loewenstein, and O'Donoghue, 2002; O'Donoghue and Rabin, 1999). With home equity extraction, present-biased preferences should amplify a home-equity financed consumption shift to period 1 from the future. This leads to a larger first-period labor supply decline. The effect on second-period labor supply should be more ambiguous than without present-biased preferences. While impatience lowers second-period labor supply by increasing the home-equity-financed consumption transfer from period 3 to period 2, higher debt servicing requirements due to higher first-period home equity withdrawal should have an offsetting effect.

For comparative statics of l_1^* with respect to E_1^*, first plug in the budget constraint into the first-period FOCs:

$$u_c[w(1-l_1)-r\pi H_0+E_1-A_1,l_1]=\frac{u_l[w(1-l_1)-r\pi H_0+E_1-A_1,l_1]}{w}.$$

Then, differentiation with respect to E_1 yields:

$$u_{c_1c_1}\left(-w\frac{dl_1}{dE_1}+1\right)+u_{c_1l_1}\frac{dl_1}{dE_1}=\frac{1}{w}\left[u_{c_1l_1}\left(-w\frac{dl_1}{dE_1}+1\right)+u_{l_1l_1}\frac{dl_1}{dE_1}\right],$$

$$\frac{dl_1^*}{dE_1}=\frac{-wu_{c_1c_1}+u_{c_1l_1}}{-w^2u_{c_1c_1}-u_{l_1l_1}+2wu_{c_1l_1}}\lesseqgtr 0.$$

Combining this equation and the previously derived sign condition for dl_1^*/da, we see that the sign of dl_1^*/da is ambiguous with, as we write in the main text:

$$sign\left[\frac{dl_1^*}{da}\right]=sign\left[\frac{dl_1^*}{dE_1^*}\right]=sign\left[\frac{-wu_{c_1c_1}+u_{c_1l_1}}{-w^2u_{c_1c_1}-u_{l_1l_1}+2wu_{c_1l_1}}\right].$$

Similarly, we can derive the equation for the sign of dc_1^*/da.

On the other hand, if utility is non-separable in c and l, then even the unambiguous effect of easier credit access on labor supply in period 1 disappears. In this case, based on the system of FOCs, comparative statics of c_1^* and l_1^* with respect to a, yield:

$$sign\left[\frac{dc_1^*}{da}\right]=sign\left[\frac{-u_{l_1l_1}+wu_{c_1l_1}}{-w^2u_{c_1c_1}-u_{l_1l_1}+2wu_{c_1l_1}}\right],$$

$$sign\left[\frac{dl_1^*}{da}\right]=sign\left[\frac{-wu_{c_1c_1}+u_{c_1l_1}}{-w^2u_{c_1c_1}-u_{l_1l_1}+2wu_{c_1l_1}}\right].$$

Assuming convex preferences with diminishing marginal utility of consumption and leisure ($u_{cc}\leq 0$ and $u_{ll}\leq 0$), the direction of the effect of a is ambiguous and depends on the magnitude of the cross derivatives relative to the second order derivatives. In the special case with utility separable in consumption and leisure ($u_{cl} = 0$), improved credit access unambiguously (weakly) increases consumption and leisure in period 1, and hence lowers labor supply.

Thus, the effect of credit access on consumption and leisure in period 1 is analogous to the income effect in standard labor supply models; preferences separable in c and l imply that both are normal goods and, therefore, improved credit access has positive income effects. However, if consumption and leisure are non-separable ($u_{cl} < 0$), the theoretical prediction of the effects of improved credit access could be ambiguous.