Online Appendix for
Did the Paycheck Protection Program Help Small Businesses? Evidence from Commercial Mortgage-Backed Securities

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*In this study, we examine the broader economic effects of the U.S. federal government's Paycheck Protection Program (PPP) by focusing on the performance of securitized commercial mortgages. We provide novel evidence for spillover effects of government interventions in the face of economic crises. We find that the PPP reduced mortgage delinquencies by approximately $36 billion in 2020. The strongest effects occur when PPP funds targeted businesses in areas most affected by COVID-19, where banks overperformed in providing PPP loans, and among mortgages on properties in retail and lodging. Thus, PPP relief to small businesses eased economic distress beyond the labor market. **This document contains additional material that support the principle manuscript.**
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Section A. Mapping PPP Loans to CMBS Mortgages

In this appendix, we explain the process we used to map PPP loans to CMBS mortgages. PPP loans are issued to qualified borrowers with small businesses that may be located in commercial buildings that could be collateral of CMBS mortgages. Hence, we used the addresses of borrowers of 4,042,406 PPP loans disclosed by the SBA data and the addresses of 15,560 properties backing single-asset CMBS mortgages in the Trepp data for this match. We excluded from those counts PPP loans and CMBS mortgages with missing address information, except for 477 CMBS mortgages that we were able to recover their addresses using the *Latitude* and *Longitude* of the collateral. We note that about 10% of the 4,456,442 PPP loans in the SBA data, and about 1.8% of the 15,848 single-asset CMBS mortgages, have missing address information.

We began the mapping process by standardizing the addresses for both the CMBS properties and PPP borrowers using the *Street Address*, *ZIP code*, *City*, and *State* fields. For example, "East XYZ Road" and "east X Y Z Rd" would both be rewritten as "E XYZ Rd". We then conducted an exact match by merging the standardized PPP addresses to the standardized CMBS addresses. Of course, multiple PPP borrowers could be mapped to one CMBS property since there may be more than one tenant in the given building who received a PPP loan. However, one challenge is that the CMBS addresses may represent multi-unit or multi-block buildings (e.g., "1003-1555 ABC Blvd"). In such cases, we allowed the PPP street number to fall within the range of street numbers in the CMBS address. For instance, if a PPP address is "1111 ABC Blvd" and the CMBS address is "1003-1555 ABC Blvd," we recorded them as a match. Overall, we matched 24,015 PPP loans to 4,924 CMBS mortgages.

Section B. Bootstrap Algorithm

To obtain t-statistics based on bootstrapped standard errors in Table 2, we follow the procedure below:

1) Limit the data to the sample in use and identify the number of unique mortgages.

2) Randomly select mortgages with replacement, constructing a new sample with the same number of mortgages as the original sample.

3) Create a new mortgages id to distinguish cases where a mortgage is selected more than once in a bootstrap iteration.

4) Estimate the parameters of Equation (3) using the new sample and appropriate cohort specifications. Use the new mortgage id to identify unit-level fixed effects.

5) Use Equations (4) and (5) to estimate and collect the average treatment response (ATR) at each relative event time l, the average post-treatment ATR, and the average pre-treatment ATR.

6) Repeat steps 2 to 5 for a total of 1,000 iterations.

7) Calculate the standard error for each ATR estimate, and then use the resulting standard errors and ATR estimates from the original sample to compute t-statistics.

SECTION C. CONTROL VARIABLES

In our robustness check, we include a number of control variables to account for confounding factors. We consider time-varying location controls at the county level, including the monthly COVID-19 rate, unemployment rate, and delinquency rate of neighboring commercial properties. The COVID-19 rate and unemployment rate control for contemporary local economic conditions that may correlate with the timing of the PPP's implementation and default decisions, whereas the county delinquency rate controls for possible spillover effects from mortgage distress, as in Gupta (2019). The COVID-19 rate is measured as the number of newly reported COVID-19 cases in the property's county during month $t-1$, divided by the population of county. The delinquency rate is calculated as the total number of neighboring commercial mortgages in county that are 30+ days past due on payments, divided by the total number of outstanding mortgages in the same county as of time $t-1$. We exclude the subject mortgage from the delinquency rate estimate.

We also consider time-varying controls at the loan level, which includes the contract rate spread and current LTV ratio. Contract rate spread is measured as the difference between the current mortgage contract rate and the 10-year Treasury bill, which we obtain from the Federal Reserve Bank of St. Louis. The current LTV ratio is measured as the outstanding loan balance divided by the current property value. We estimate the current property value by inflating the value at securitization by the appropriate property sector's National Association of Real Estate Investment Trusts index. We winsorize the LTV and contract spread at the 1% tails. Together, the contract spread and current LTV account for changes in delinquency risk that may be attributed to idiosyncratic changes in loan terms or characteristics over time. Moreover, they reflect volatility in the real estate ownership markets and mortgage markets.

Section D. Additional Tables

Table A.1—Descriptive Statistics of Securitized and Portfolio Mortgages

Panel A: Securitized Mortgages	Property Type			
	Industrial	Lodging	Office	Retail
Securitization Value ($millions)	9	17	28	11
Securitization Amount ($millions)	6	10	17	7
Origination Term (years)	10	10	10	10
Securitization LTV (%)	65	64	66	67
Rate Spread (basis points)	240	264	230	235
IO share (%)	14	8	29	18
Recourse share (%)	0	0	1	0
N	2,269	2,554	3,485	6,948
Share of N (%)	15	17	23	46
Panel B: Portfolio Mortgages	Property Type			
	Industrial	Lodging	Office	Retail
Origination Value ($millions)	14	46	38	18
Origination Amount ($millions)	8	21	18	8
Origination Term (years)	8	7	7	8
Origination LTV (%)	58	57	60	57
Rate Spread (basis points)	233	264	228	228
IO share (%)	16	26	26	17
Recourse share (%)	79	66	70	76
N	5,634	1,882	9,620	11,434
Share of N (%)	20	7	34	40

This table reports descriptive statistics of commercial mortgages. Panel A displays the median value or share of key mortgage characteristics for mortgages in nonresidential CMBS provided by Trepp that were outstanding as of January 2019. Panel B displays the average values of key mortgage characteristics for mortgages in the commercial real estate portfolios of the largest banks (with $100 billion or more in assets) in the United States as reported by Glancy et al. (2021), who use data in the Y-14 H.2 Schedule for Stress Testing from 2012 to 2020. The column denotes the property type underlying the subsample of commercial mortgages.

TABLE A.2—MEAN COUNTY-LEVEL MARKET VALUE OF NCREIF AND TREPP PROPERTIES (IN $MILLIONS)

Panel A: All county observations					
Sample	NCREIF	TREPP	Difference	t-stat	d-stat
Office	63.215	45.881	-17.334	2.504	0.237
	166	327			
Retail	90.523	25.657	-64.866	11.561	0.783
	246	981			
Industrial	34.758	24.315	-10.443	4.134	0.332
	226	456			
Lodging	32.057	24.072	-7.985	1.127	0.158
	56	600			
Panel B: Overlapping county observations					
Sample	NCREIF	TREPP	Difference	t-stat	d-stat
Office	72.159	76.847	4.689	-0.4	0.051
	123	123			
Retail	91.886	47.653	-44.233	3.964	0.364
	230	230			
Industrial	35.211	29.122	-6.089	1.51	0.166
	165	165			
Lodging	31.201	41.018	9.817	-1.298	0.267
	47	47			

This table reports the mean county-level market value of institution-grade, nonresidential commercial properties (6,413) from the National Council of Real Estate Investment Fiduciaries (NCREIF) as of 2019Q4, and that of collateral property for more than 15,000 nonresidential CMBS mortgages from Trepp as of December 2019. Panel A shows statistics based on the full county-level cross-section by property type, whereas Panel B shows statistics based on the counties that appear in both the NCREIF and Trepp samples. The number of observations (i.e., counties) for each subsample is reported in the even rows.

TABLE A.3—SUMMARY STATISTICS FOR SBA PPP LOANS

Panel A	Matched to CMBS data?				
Full Sample of PPP Loans	No	Yes	Difference	t-stat	d-stat
Jobs reported	12.70	18.63	5.93	25.98	0.17
PPP loan size ($1,000s)	111.62	184.21	72.59	29.72	0.19
Observations	4,432,427	24,015			
Panel B	Matched to CMBS data?				
Reported Rent Subsample of PPP Loans	No	Yes	Difference	t-stat	d-stat
Payroll proceed ($1,000s)	133.81	157.60	23.79	3.51	0.06
Payroll share (%)	88.21	77.88	-10.33	-0.35	-0.01
Rent proceed ($1,000s)	16.51	20.96	4.44	4.54	0.08
Rent share (%)	15.30	15.68	0.38	0.09	0.00
Observations	444,447	3,408			

Panel A reports summary statistics on non-missing variables for unique PPP loans approved in 2020 by whether they were matched to businesses located in CMBS properties. Panel B reports summary statistics on the intended allocation of PPP funds between payroll expenses and rent expenses among businesses that reported they would use PPP funds to pay rent.

TABLE A.4—SUMMARY STATISTICS BY PPP TENANTS

Variables	Matched to SBA PPP Data?		Difference	t-stat	d-stat
	No	Yes			
Securitization loan balance ($millions)	16.90	23.40	6.51	8.08	0.14
Securitization property value ($millions)	45.61	90.54	44.93	11.38	0.20
Current LTV (%)	51.17	54.21	3.04	8.71	0.15
Contract spread (%)	2.43	2.15	-0.29	-19.66	-0.34
Origination year	2013	2014	1.41	20.19	0.34
Origination term (months)	128.38	120.02	-8.36	-11.99	-0.21
Remaining term (months)	65.46	72.50	7.04	12.43	0.21
Interest only	0.18	0.17	-0.01	-1.83	-0.03
Recourse	0.01	0.00	-0.00	-1.97	-0.03
Late payment	0.08	0.03	-0.04	-10.63	-0.18
Delinquent 30 days or more	0.06	0.01	-0.05	-12.65	-0.22
Delinquent 60 days or more	0.06	0.01	-0.04	-12.75	-0.22
Special servicing	0.06	0.02	-0.04	-12.03	-0.21
Observation	10,636	4,924			

This table reports summary statistics on non-missing variables as of January 2019 for unique mortgages with and without PPP tenants in the full CMBS sample restricted to mortgages with a single underlying property. The t-statistic is from a test of the mean difference against the null hypothesis of "no difference." The d-statistic is the mean difference divided by the pooled standard deviation. A d-statistic greater than 0.8 in absolute terms is considered large, and one in absolute term lower than 0.2 is considered small.

TABLE A.5—PPP TREATMENT INTENSITY EFFECT ON LOAN PERFORMANCE

Dep. var.: 1[30+ Days Delinquent]	(1)	(2)	(3)	(4)	(5)	(6)
$D^{l \geq 0}$	0.091	0.011	0.005	0.006	0.004	0.003
	(48.551)	(0.922)	(0.573)	(0.675)	(0.431)	(0.339)
PPP/Debt Service	-0.001	-0.001				
	(-5.587)	(-1.265)				
$D^{l \geq 0} \times$ PPP/Debt Service	-0.010	-0.010	-0.010	-0.008	-0.010	-0.009
	(-22.917)	(-11.844)	(-12.317)	(-11.014)	(-11.594)	(-9.373)
COVID-19 rate (%)				0.005		
				(1.239)		
Unemployment rate (%)				0.000		
				(0.601)		
Delinquency rate (%)				0.002		
				(6.162)		
Contract spread (%)				-0.011		
				(-0.622)		
Current LTV (%)				0.001		
				(11.399)		
Observations	117,537	117,537	117,537	117,537	117,537	117,537
Adjusted R^2	0.0371	0.0387	0.511	0.517	0.517	0.552
Constant	✓	✓	✓	✓	✓	✓
Loan FE			✓	✓	✓	✓
Year × Month FE		✓	✓	✓		
State × Year × Month FE					✓	
County × Year × Month FE						✓

This table reports OLS regressions of the 30+ days delinquency status on interactions of $D^{l \geq 0}$ and *PPP/Debt Service* using the PPP-CMBS matched sample of loan-level monthly performance records from January 2019 to December 2020 with different fixed effects and controls. $D^{l \geq 0}$ is one if the relative time l that a CMBS mortgage has been exposed to PPP funds is positive ($l \geq 0$), and zero otherwise. *PPP/Debt Service* is constructed as the static ratio of total 2020 PPP funds in dollars to the scheduled annual mortgage debt services (using January 2019 scheduled debt services multiplied by 12). *COVID-19 rate* is the lagged monthly county new COVID-19 cases over population. *Unemployment rate* is the lagged monthly county unemployment rate. *Delinquency rate* is the lagged monthly county-level neighboring property delinquency rate. *Contract spread* is the difference between the current mortgage rate and the yield on the 10-year Treasury bill. *Current LTV* is the current mortgage LTV ratio. Robust t-statistics clustered by CMBS mortgage are in parentheses.

TABLE A.6—DYNAMIC PPP TREATMENT INTENSITY EFFECTS ON LOAN PERFORMANCE

Dep. var.: 1[30+ Days Delinquent]	(1)	(2)	(3)	(4)
D^{-5+} × PPP/Debt Service	0.001	0.001	0.001	-0.352
	(2.566)	(2.418)	(2.202)	(-0.455)
D^{-4} × PPP/Debt Service	0.001	0.001	0.001	0.290
	(1.847)	(1.685)	(1.303)	(0.852)
D^{-3} × PPP/Debt Service	0.000	0.000	0.000	-0.082
	(0.359)	(0.412)	(0.374)	(-1.439)
D^{-2} × PPP/Debt Service	0.000	0.000	0.000	0.003
	(1.155)	(0.987)	(0.299)	(0.741)
D^{0} × PPP/Debt Service	-0.006	-0.006	-0.005	-0.006
	(-7.909)	(-7.837)	(-5.812)	(-7.855)
D^{1} × PPP/Debt Service	-0.012	-0.012	-0.010	-0.012
	(-10.834)	(-10.210)	(-8.062)	(-10.236)
D^{2} × PPP/Debt Service	-0.011	-0.011	-0.010	-0.011
	(-11.714)	(-10.813)	(-8.877)	(-10.730)
D^{3} × PPP/Debt Service	-0.010	-0.010	-0.009	
	(-11.344)	(-10.628)	(-8.540)	
D^{4} × PPP/Debt Service	-0.010	-0.009	-0.008	
	(-10.378)	(-9.780)	(-7.807)	
D^{5} × PPP/Debt Service	-0.010	-0.010	-0.009	
	(-10.007)	(-9.592)	(-7.881)	
D^{6} × PPP/Debt Service	-0.009	-0.009	-0.008	
	(-10.249)	(-9.778)	(-8.043)	
D^{7} × PPP/Debt Service	-0.009	-0.009	-0.008	
	(-9.972)	(-9.308)	(-7.761)	
Observations	117,537	117,537	117,537	19,663
Adjusted R^2	0.511	0.517	0.552	0.592
Sup-t	2.862	2.844	2.841	2.835
Constant	✓	✓	✓	✓
Loan FE	✓	✓	✓	✓
Year × Month FE	✓			
State × Year × Month FE		✓		✓
County × Year × Month FE			✓	

This table reports OLS regressions of the 30+ days delinquency status on interactions of the PPP event time dummies (D^l) and *PPP/Debt Service* using the PPP-CMBS matched sample of loan-level monthly performance records from January 2019 to December 2020 with different fixed effects. The sample in column (4) is restricted to monthly performance records from January 2020 to July 2020. Each event time dummy (D^l) indicates the relative time l in months since the treatment date (or initial PPP exposure). Robust t-statistics clustered by CMBS mortgage are in parentheses. The sup-t statistic is the 95% critical value for simultaneous multiple hypotheses testing.

TABLE A.7—PPP TREATMENT INTENSITY EFFECT ON OTHER LOAN PERFORMANCE MEASURES

Dep. var.:	(1) 1[Late]	(2) 1[Special Servicing]	(3) 1[60+ Days Delinquent]
$D^{t \geq 0}$	-0.007	0.007	0.007
	(-0.587)	(1.214)	(1.592)
$D^{t \geq 0}$ × PPP/Debt Service	-0.013	-0.009	-0.007
	(-12.268)	(-11.116)	(-10.683)
Observations	117,537	117,537	117,537
Adjusted R2	0.438	0.560	0.558
Constant	✓	✓	✓
Loan FE	✓	✓	✓
State × Year × Month FE	✓	✓	✓

This table reports OLS regressions of the 30+ days delinquency status on interactions of $D^{l \geq 0}$ and *PPP/Debt Service* using the PPP-CMBS matched sample of loan-level monthly performance records from January 2019 to December 2020. The column header defines the loan performance dependent variable. *Late* flags whether a debt service payment is past due even if the borrower is still in a grace period (the payment is fewer than 30 days past due). *60-Day Delinquent* flags whether a debt service payment is 60+ days late. *Special Service* flags whether a loan is in special servicing. $D^{l \geq 0}$ is one if the relative time l that a CMBS mortgage has been exposed to PPP funds is positive ($l \geq 0$), and zero otherwise. *PPP/Debt Service* is constructed as the static ratio of total 2020 PPP funds in dollars to the scheduled annual mortgage debt services (using January 2019 scheduled debt services multiplied by 12). Robust t-statistics clustered by CMBS mortgage are in parentheses.

TABLE A.8—PPP TREATMENT INTENSITY USING FIRST MORTGAGE PAY DAY

Dep. var.: 1[30+ Days Delinquent]	(1)	(2)
Adj. $D^{l \geq 0}$	0.013	0.012
	(1.710)	(1.670)
Adj. $D^{l \geq 0}$ × PPP/Debt Service	-0.010	-0.008
	(-11.574)	(-10.107)
COVID-19 rate (%)		0.001
		(0.082)
Unemployment rate (%)		0.000
		(0.344)
Delinquency rate (%)		0.002
		(4.000)
Contract spread (%)		-0.013
		(-0.726)
Current LTV (%)		0.001
		(11.385)
Observations	116,555	116,555
Adjusted R^2	0.493	0.499
Constant	✓	✓
Loan FE	✓	✓
State × Year × Month FE	✓	✓

This table reports OLS regressions of the 30+ days delinquency status on the interactions of Adj.$D^{l \geq 0}$ and *PPP/Debt Service* using the PPP-CMBS matched sample of loan-level monthly performance records from January 2019 to December 2020. The first mortgage due date in the amortization schedule is used to infer the monthly payment due date. This relaxes the assumption that all mortgages are due at the first of the month in arrears. Hence, the post-treatment dummy (Adj. $D^{l \geq 0}_{i,t}$) takes a value of one if initial exposure to PPP occurs before the inferred current mortgage due date, and zero otherwise. *PPP/Debt Service* is constructed as the static ratio of total PPP funds in dollars using the initial approval amount in 2020 to scheduled annual mortgage debt services (using January 2019 scheduled debt services multiplied by 12). *COVID-19 rate* is the lagged monthly county new COVID-19 cases over population. *Unemployment rate* is the lagged monthly county unemployment rate. *Delinquency rate* is the lagged monthly county-level neighboring property delinquency rate. *Contract spread* is the difference between the current mortgage rate and the yield on the 10-year Treasury bill. *Current LTV* is the current mortgage LTV ratio. Robust t-statistics clustered by CMBS mortgage are in parentheses.

TABLE A.9—COX HAZARD MODEL: PPP POLICY EFFECT ON LOAN PERFORMANCE

Dep. var.: 1[30+ Days Delinquent]	(1)	(2)
Cumulative PPP/Debt Service	0.609	0.649
	(-6.917)	(-5.965)
COVID-19 rate (%)		1.230
		(1.841)
Unemployment rate (%)		1.001
		(0.069)
Delinquency rate (%)		1.009
		(2.246)
Contract spread (%)		1.676
		(5.437)
Current LTV (%)		1.008
		(5.853)
Observations	48,730	48,730
Constant	✓	✓
Loan FE	✓	✓
Year × Month FE	✓	✓

This table reports hazard ratios of Cox hazard regressions of the 30+ days delinquency status on the cumulative PPP treatment intensity using monthly performance records from January 2020 to December 2020 for mortgages in the PPP-CMBS matched sample that are not delinquent for 30+ days as of January 2020. *Cumulative PPP/Debt service* is constructed as the time-varying ratio of cumulative PPP funds in dollars that a CMBS mortgage received before the previous month using the initial approval amount to scheduled annual mortgage debt services ratio (using January 2019 scheduled debt services multiplied by 12). It is zero if there were no PPP funds distributed to a CMBS mortgage as of the previous month. *COVID-19 rate* is the lagged monthly county new COVID-19 cases over population. *Unemployment rate* is the lagged monthly county unemployment rate. *Delinquency rate* is the lagged monthly county-level neighboring property delinquency rate. *Contract spread* is the difference between the current mortgage rate and the yield on the 10-year Treasury bill. *Current LTV* is the current mortgage LTV ratio. Robust t-statistics clustered by CMBS mortgage are in parentheses.

TABLE A.10—NON-LINEAR PPP TREATMENT INTENSITY EFFECT

Dep. var.: 1[30+ Days Delinquent]	(1) Quadratic	(2) Cubic
$D^{t \geq 0}$	0.011	0.017
	(1.233)	(1.838)
$D^{t \geq 0} \times$ PPP/Debt Service	-0.022	-0.035
	(-11.538)	(-9.826)
$D^{t \geq 0} \times$ (PPP/Debt Service)^2	0.001	0.003
	(7.758)	(6.470)
$D^{t \geq 0} \times$ (PPP/Debt Service)^3		-0.000
		(-4.690)
Observations	117,537	117,537
Adjusted R^2	0.518	0.519
Constant	✓	✓
Loan FE	✓	✓
State $\times$ Year $\times$ Month FE	✓	✓

This table reports OLS regressions of the 30+ days delinquency status on the interactions of $D^{l \geq 0}$ and *PPP/Debt Service* using the PPP-CMBS matched sample of loan-level monthly performance records from January 2019 to December 2020. $D^{l \geq 0}$ is one if the relative time l that a CMBS mortgage has been exposed to PPP funds is positive ($l \geq 0$), and zero otherwise. *PPP/Debt Service* is constructed as the static ratio of total PPP funds in dollars using the initial approval amount in 2020 to scheduled annual mortgage debt services (using January 2019 scheduled debt services multiplied by 12). (*PPP/Debt Service*)^2 is the squared term of *PPP/Debt Service*, and (*PPP/Debt Service*)^3 is the cubic term of *PPP/Debt Service*. Robust t-statistics clustered by CMBS mortgage are in parentheses.

TABLE A.11—PPP TREATMENT INTENSITY EFFECTS AND HETEROGENEOUS PANDEMIC RESPONSE

Dep.var.: 1[30+ Days Delinquent]	(1)	(2)
$D^{t \geq 0}$	0.006	0.007
	(0.615)	(0.717)
$D^{t \geq 0}$ × PPP/Debt Service	-0.011	-0.008
	(-11.418)	(-9.873)
COVID-19 rate (%)	0.024	0.028
	(1.746)	(1.990)
COVID-19 rate (%) × PPP/Debt Service D2	-0.011	-0.013
	(-0.629)	(-0.693)
COVID-19 rate (%) × PPP/Debt Service D3	-0.032	-0.034
	(-1.853)	(-1.998)
COVID-19 rate (%) × PPP/Debt Service D4	-0.020	-0.024
	(-1.166)	(-1.389)
COVID-19 rate (%) × PPP/Debt Service D5	-0.024	-0.030
	(-1.372)	(-1.683)
COVID-19 rate (%) × PPP/Debt Service D6	-0.030	-0.035
	(-1.772)	(-2.052)
COVID-19 rate (%) × PPP/Debt Service D7	-0.058	-0.062
	(-3.694)	(-4.009)
COVID-19 rate (%) × PPP/Debt Service D8	-0.036	-0.042
	(-2.211)	(-2.600)
COVID-19 rate (%) × PPP/Debt Service D9	-0.028	-0.037
	(-1.654)	(-2.190)
COVID-19 rate (%) × PPP/Debt Service D10	-0.010	-0.025
	(-0.636)	(-1.577)
Unemployment rate (%)		0.001
		(0.383)
Delinquency rate (%)		0.002
		(4.155)
Contract spread (%)		-0.008
		(-0.451)
Current LTV (%)		0.001
		(11.717)
Observations	117,537	117,537
Adjusted R^2	0.517	0.522
Constant	✓	✓
Loan FE	✓	✓
State × Year × Month FE	✓	✓

This table reports OLS regressions of the 30+ days delinquency status on the interactions of $D^{l \geq 0}$ and *PPP/Debt Service* and the interactions of *PPP/Debt Service* decile groups and regional *COVID-19 rate* using the PPP-CMBS matched sample of loan-level monthly performance records from January 2019 to December 2020. $D^{l \geq 0}$ is one if the relative time l that a CMBS mortgage has been exposed to PPP funds is positive ($l \geq 0$), and zero otherwise. *PPP/Debt Service D2, D3, . . . , D10* are one for CMBS mortgages in *PPP/Debt Service* deciles 2, 3, . . . 10, respectively. *PPP/Debt Service D1* for CMBS mortgages in the first *PPP/Debt Service* decile (lowest) is omitted as the base. PPP/Debt service deciles are calculated using the static *PPP/Debt Service* ratio within each property type. *PPP/Debt Service* is constructed as the static ratio of total 2020 PPP funds in dollars to scheduled annual mortgage debt services (using January 2019 scheduled debt services multiplied by 12). *COVID-19 rate* is the lagged monthly county new COVID-19 cases over population. *Unemployment rate* is the lagged monthly county unemployment rate. *Delinquency rate* is the lagged monthly county-level neighboring property delinquency rate. *Contract spread* is the difference between the current mortgage rate and the yield on the 10-year Treasury bill. *Current LTV* is the current mortgage LTV ratio. Robust t-statistics clustered by CMBS mortgage are in parentheses.

Table A.12—PPP Treatment Intensity Effect Excluding Real Estate PPP Borrowers

Dep. var.: 1[30+ Days Delinquent]	(1)	(2)
$D^{l \geq 0}$	0.004	0.006
	(0.444)	(0.581)
$D^{l \geq 0} \times$ PPP/Debt Service	-0.011	-0.009
	(-10.922)	(-9.554)
COVID-19 rate (%)		0.003
		(0.367)
Unemployment rate (%)		0.001
		(0.373)
Delinquency rate (%)		0.002
		(4.217)
Contract spread (%)		-0.009
		(-0.499)
Current LTV (%)		0.001
		(10.880)
Observations	109,309	109,309
Adjusted R^2	0.516	0.520
Constant	✓	✓
Loan FE	✓	✓
State × Year × Month FE	✓	✓

This table reports OLS regressions of the 30+ days delinquency status on the interactions of $D^{l \geq 0}$ and *PPP/Debt Service* using the PPP-CMBS matched sample of loan-level monthly performance records from January 2019 to December 2020 but excluding mortgages linked to a PPP borrower in the real estate industry. $D^{l \geq 0}$ is one if the relative time l that a CMBS mortgage has been exposed to PPP funds is positive ($l \geq 0$), and zero otherwise. *PPP/Debt Service* is constructed as the static ratio of total PPP funds in dollars using the initial approval amount in 2020 to scheduled annual mortgage debt services (using January 2019 scheduled debt services multiplied by 12). *COVID-19 rate* is the lagged monthly county new COVID-19 cases over population. *Unemployment rate* is the lagged monthly county unemployment rate. *Delinquency rate* is the lagged monthly county-level neighboring property delinquency rate. *Contract spread* is the difference between the current mortgage rate and the yield on the 10-year Treasury bill. *Current LTV* is the current mortgage LTV ratio. Robust t-statistics clustered by CMBS mortgage are in parentheses.

Table A.13—Descriptive Statistics of NCREIF Properties

	Retail		Lodging		Office		Industrial	
Variable	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Market Value/SQFT ($)	570.347	1034.78	252.79	152.733	696.152	8266.536	161.684	905.744
Square Feet (1,000s)	234.420	300.364	144.295	122.497	270.683	325.434	265.432	374.216
NOI/SQFT ($)	5.425	4.236	4.507	4.057	5.583	3.736	1.565	1.558
CAPEX/SQFT ($)	1.528	8.265	1.978	3.159	2.844	11.173	0.675	6.703
Leveraged share	0.519	0.5	0.795	0.406	0.565	0.496	0.283	0.451
Observations	1,420		78		1,825		4,701	

This table reports descriptive statistics of unique institution-grade, nonresidential commercial properties from the National Council of Real Estate Investment Fiduciaries (NCREIF) that were matched to PPP loans by property type. The statistics are based on the earliest available record for each property in the NCREIF dataset from 2019Q1 to 2020Q4. SD stands for standard deviation. Market Value/SQFT is the property's estimated market value per square foot. Square Feet is the property's total area that may be leased. NOI/SQFT is the net operating income per square foot, winsorized at the 1% tails. CAPEX/SQFT is the recorded capital expenditures per square foot. Leverage share is the proportion of properties with an outstanding mortgage.
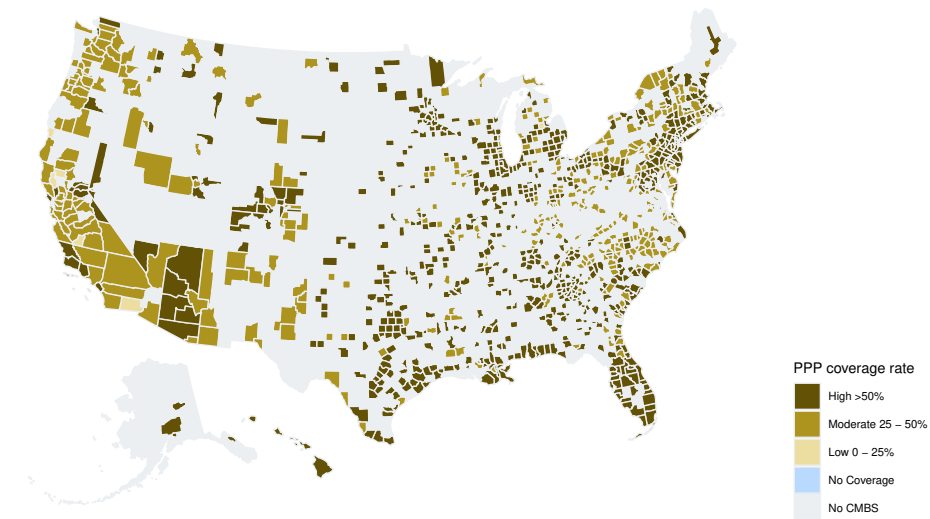
Section E. Additional Figures

FIGURE A.1. **PPP Cumulative Coverage in U.S. Counties by 2020**

This figure illustrates the PPP coverage rate of the U.S. counties that are represented in the full CMBS sample. The PPP coverage rate is measured as the total number of approved PPP loans originated in a county as of the end of 2020 divided by the number of business establishments in that county. CMBS counties that by 2020 had more than 50% of their establishments covered by PPP loans are labeled as high coverage and shown in dark brown. Counties that by 2020 had more than 25% but less than 50% of their establishments covered by PPP loans are labeled as moderate coverage and shown in brown. Counties that by 2020 had no more than 25% of their establishments covered by PPP loans are marked as low coverage and shown in light brown. CMBS counties with no PPP coverage at all are depicted in blue. Out-of-sample counties are shown in grey.
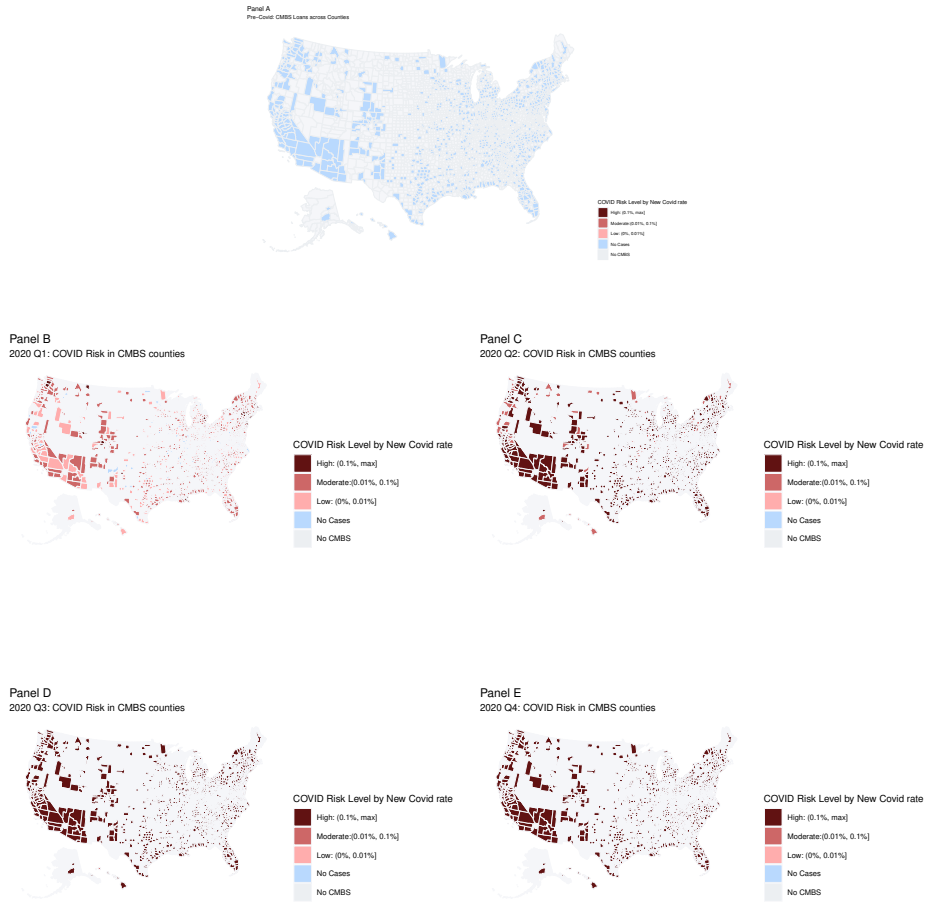
Figure A.2. **COVID-19 Exposure in U.S. Counties**

This figure provides snapshots of the cumulative COVID-19 cases per population in U.S. counties (in the full CMBS sample) at each quarter-end of 2020. Counties with COVID-19 cases greater than 0 to 0.01 per population (0-0.01%] are labeled as low risk and shown in light pink, above 0.01% to 0.1% as moderate risk and shown in coral, and above 0.1% as high risk and shown in red. Counties without any COVID-19 cases are depicted in blue. Out-of-sample counties are shown in grey. There are more than 1,100 counties in our sample, representing more than 36% of the counties nationwide.
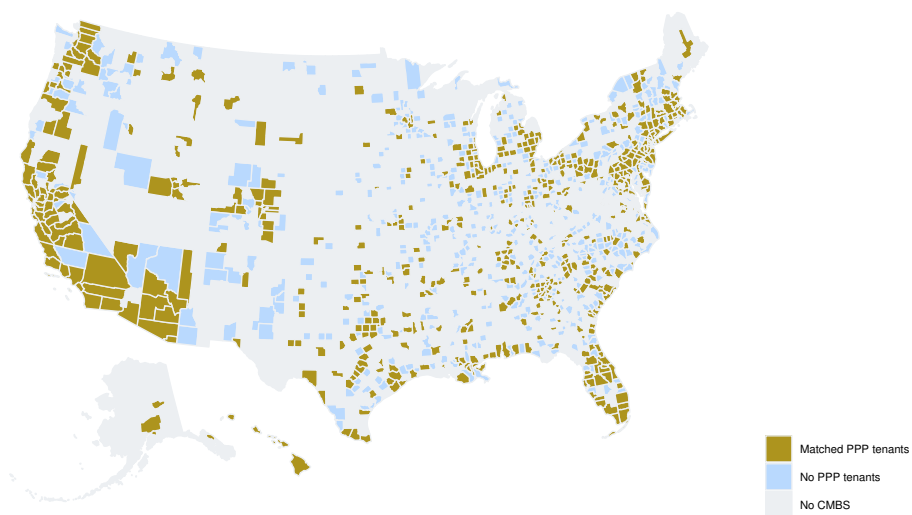
FIGURE A.3. **PPP Tenants Map**

This figure provides a snapshot of counties with single-asset collateralized CMBS mortgages that had at least one tenant approved to receive a PPP loan. A CMBS mortgage is considered to have a PPP tenant if the PPP loan borrower has the same address as the CMBS mortgage property. Counties highlighted in blue do not have any CMBS mortgages with tenants who received PPP loans. Counties in grey do not have any CMBS mortgages at all.
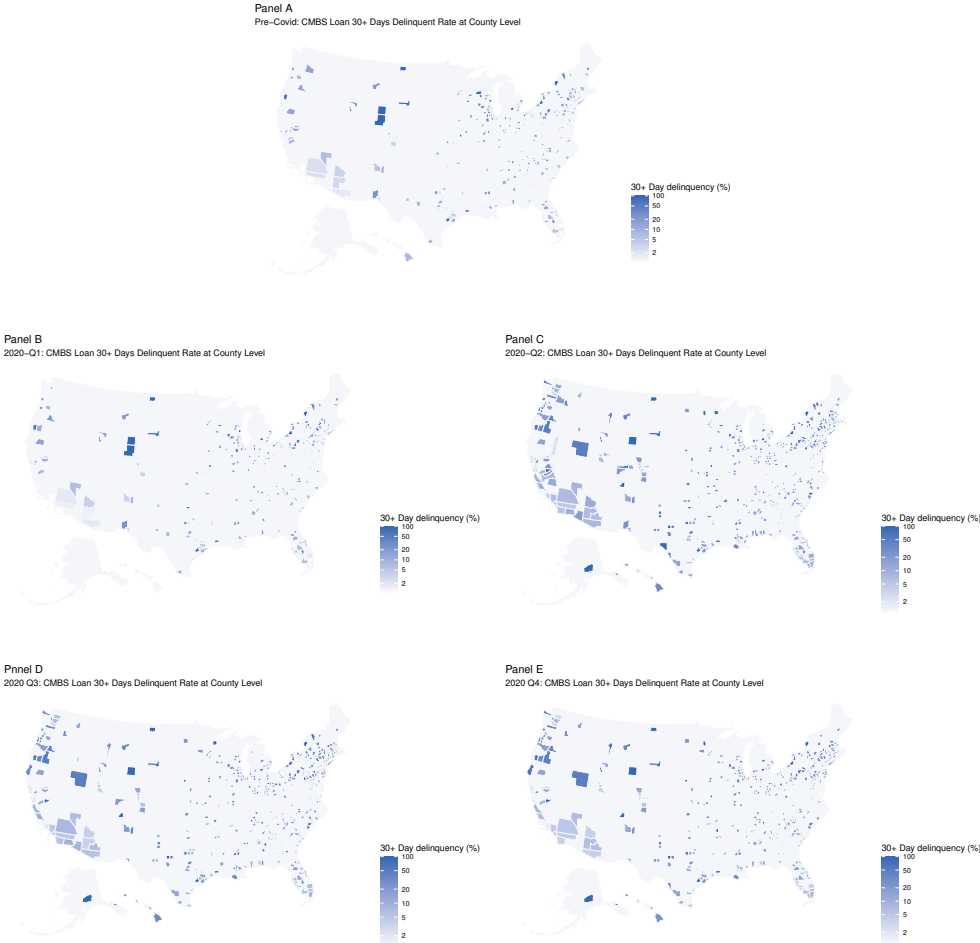
Panel A
Pre–Covid: CMBS Loan 30+ Days Delinquent Rate at County Level

Panel B
2020–Q1: CMBS Loan 30+ Days Delinquent Rate at County Level

Panel C
2020–Q2: CMBS Loan 30+ Days Delinquent Rate at County Level

Pnnel D
2020 Q3: CMBS Loan 30+ Days Delinquent Rate at County Level

Panel E
2020 Q4: CMBS Loan 30+ Days Delinquent Rate at County Level

FIGURE A.4.   **30+ Days Delinquency Rate Across U.S. Counties**

This figure provides snapshots of the 30+ days delinquency rate in U.S. counties (in our sample) at each quarter-end of 2020. The darker the county is shaded (from gray to blue), the higher its delinquency rate is. Out-of-sample counties are shown in grey.
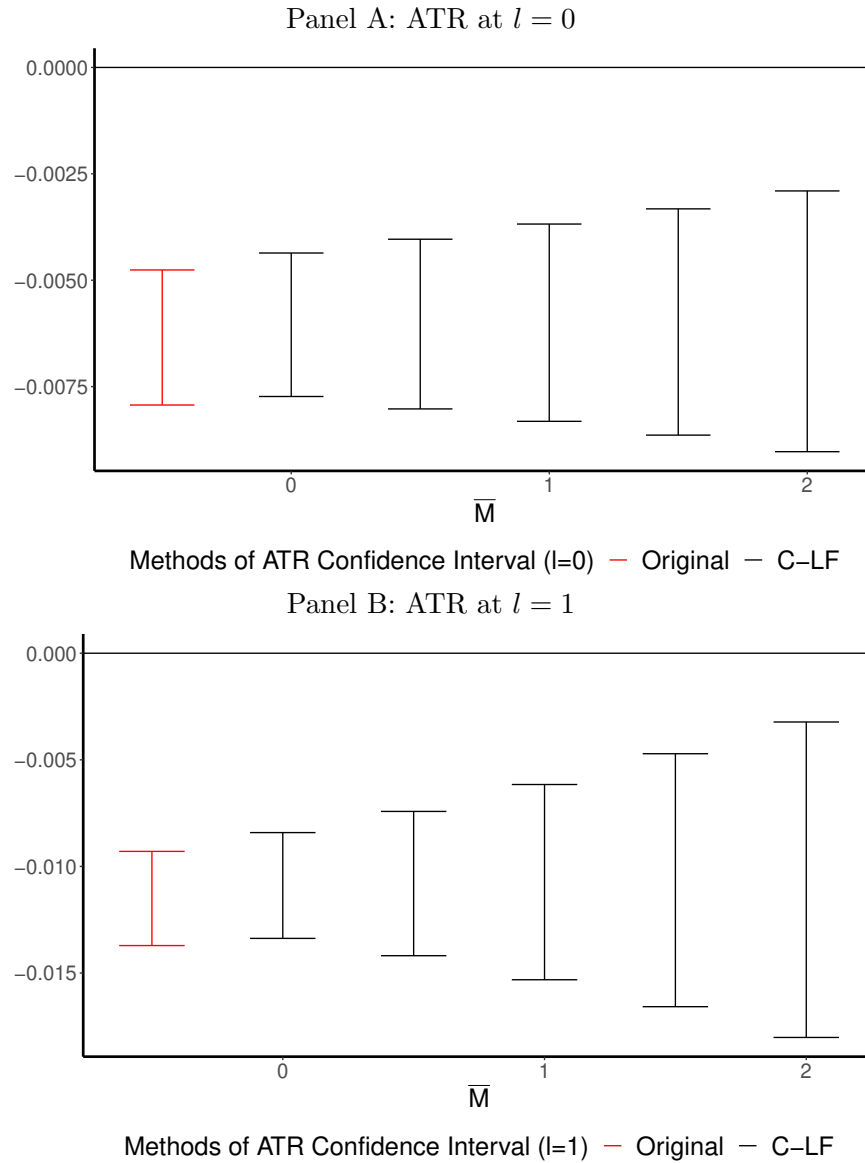
Panel A: ATR at $l = 0$

Methods of ATR Confidence Interval (l=0) — Original — C–LF

Panel B: ATR at $l = 1$

Methods of ATR Confidence Interval (l=1) — Original — C–LF

FIGURE A.5. **ATR Confidence Interval Sensitivity Analysis**

This figure display the 95% confidence intervals of the average treatment response (ATR, $\hat{\delta}_1^l$ from Equation (2)) of the 30+ days delinquency rate to the PPP/DS intensity levels following the sensitivity analysis by Rambachan and Roth (2022). Panel A plots the standard (original) confidence interval in red and the confidence intervals of ATR at $l = 0$ using Conditional Least Favourable hybrid sets (C-LF) in black when allowing a linear trend that is $\bar{M}$ times the maximum linear trend observed from the pre-treatment periods. Panel B plots such confidence intervals for the ATR at $l = 1$. The event time from the treatment date in months is denoted by l.
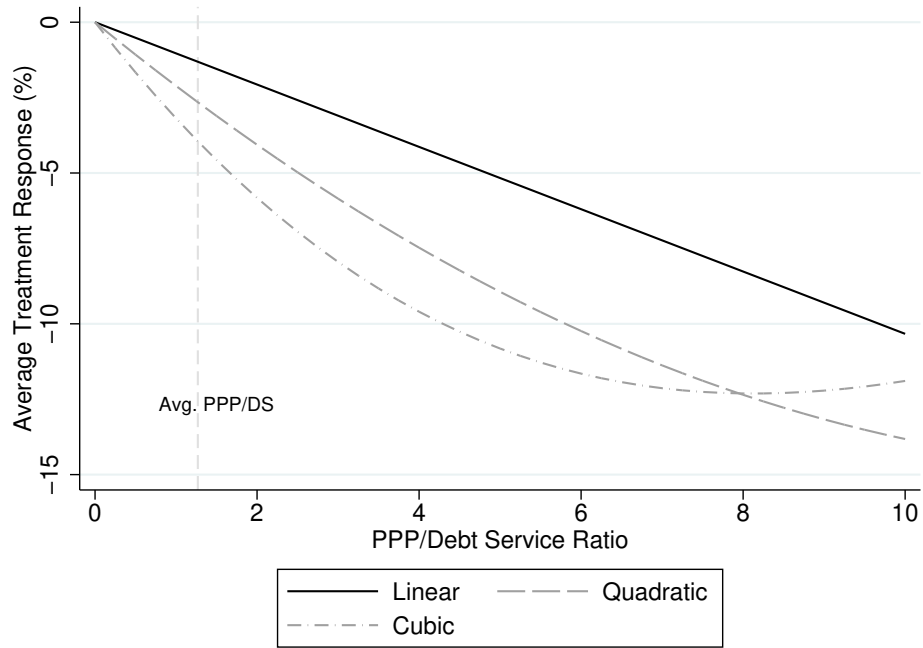
FIGURE A.6. **ATR Over PPP Intensity Levels**

This figure display the average treatment response (ATR) of the 30+ days delinquency rate at various PPP/DS intensity levels. The relationship between the delinquency rate and intensity level may be linear, quadratic, or cubic. The linear estimates are drawn from column (5) of Table A.5. The quadratic and cubic estimates are drawn from Table A.10. The vertical dashed line markets the average PPP/DS intensity level of 1.269.
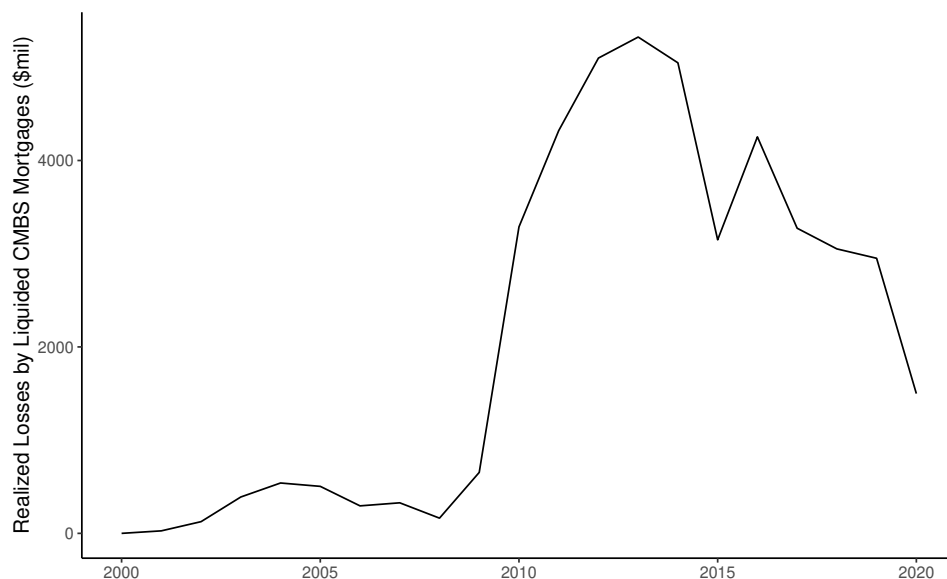
FIGURE A.7. **Historical Realized Losses by CMBS Mortgages 2000 - 2020**

This figure displays the annual realized losses incurred by CMBS mortgages liquidated in each year from 2000 to 2020 reported in the Trepp data. The CMBS mortgages included in this plot are those backed by properties in similar counties and property sectors to CMBS mortgages in our sample.

*

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Gupta, Arpit. 2019. "Foreclosure contagion and the neighborhood spillover effects of mortgage defaults." *The Journal of Finance*, 74(5): 2249–2301.

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