An Evaluation of the Paycheck Protection Program Using Administrative Payroll Microdata *

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Abstract

The Paycheck Protection Program (PPP), a principal element of the fiscal stimulus enacted by Congress in response to the COVID-19 economic shock, was intended to assist small businesses to maintain employment and wages during the crisis, as well as cover other expenses. We use administrative, high-frequency employment data from ADP—one of the world's largest payroll processing firms—to estimate the causal effect of the PPP on the evolution of payroll employment at PPP-eligible firms relative to PPP-ineligible firms, where eligibility is determined by industry-specific firm-size cutoffs. Our estimates indicate that the PPP boosted employment at eligible firms by between 2 percent to 5 percent at its peak effect around mid-May 2020. We find that the boost to employment waned thereafter and ranged from no effect to a 3 percent boost at the end of 2020. On average, these estimates imply that 3.6 million jobs were retained by the PPP as of mid-May and 1.4 million jobs were retained at the end of 2020. The cost per job retained, which we estimate at $\$113,000$ to $\$257,000$, was substantial.

JEL Classification: H25, H32, H81, E24
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1 Introduction

The start of the COVID-19 pandemic caused a dramatic plunge in U.S. economic activity. A key pillar of the fiscal stimulus measures enacted by the U.S. Congress in response was the provision of forgivable loans to small businesses through the Paycheck Protection Program (PPP). Although the PPP undoubtedly had multiple goals, its primary aim was to support small businesses—many of which lacked access to credit in the economically strained environment—in maintaining employment at pre-pandemic levels. Hence Congress's use of the word "paycheck" in the program name and its requirement that for loans to be forgiven, a majority of loan proceeds must be used to cover wages. The program was economically extremely large relative to the targeted sector: In its first year of operation, it issued forgivable loans totalling $525 billion, roughly equal to the *entire* 10-week payroll of small businesses in the U.S. Given that most PPP loan sizes were set at 10 weeks of payroll, this means that the program effectively achieved saturation.

This paper aims to provide an assessment of the PPP's efficacy in achieving its primary goal of sustaining small business employment. A significant obstacle to this assessment is the lack of publicly-available, granular, high-frequency data on employment at PPP-beneficiary and non-beneficiary firms. We surmount this obstacle by analyzing administrative data from ADP—one of the world's largest providers of personnel management services—to measure weekly, firm-level employment changes. These data allow us to observe high-frequency, firm-level employment data at weekly intervals throughout the pandemic and to identify a set of firms that are eligible to receive PPP loans and a set that are not.

Our analysis uses a dynamic difference-in-difference framework to identify the effect of the PPP on employment. To form the treatment group, we focus on firms in a range below the industry-specific employment size thresholds that define eligibility for the program—500 employees for most industries. We compare these eligible firms to those in a range above the threshold, which comprise the control group. To account for potential confounders stemming from rapidly evolving economic conditions across industries and states during the COVID

crisis, our baseline results include a rich set of fixed effects, including three-digit NAICS industry-by-week and state-by-week fixed effects.

Our analysis finds that PPP boosted employment at eligible firms, but that the effects diminished over the course of 2020. Following the disbursement of the first tranche of PPP loans, employment at eligible firms began to rise relative to employment at ineligible firms. The peak effect on employment at eligible firms ranged between 2 and 5 percent around mid-May, depending on the specification. Thereafter, the effect on employment waned gradually. By the end of our sample in the beginning of December 2020, the employment effect ranged from about 0 percent to about 3 percent. None of these December estimates, though, are precise enough to rule out that the PPP had no effect on employment at that time.

Several additional steps are required to determine the aggregate employment effect of the PPP. We first translate the above intent-to-treat estimates—which contrast eligible vs. ineligible firms—into estimates of the effect of actually receiving a PPP loan. Doing so requires an estimate of the take-up rate of the PPP in the intervals around the eligibility threshold. Using data from the Small Business Administration (SBA) on PPP loans by firm size, as well as publicly-available data on the distribution of employment across firm size from the Census Bureau, we estimate that take-up for firms with between 300 to 499 workers was substantial—around 81%. We also find that there was non-trivial take up in the relevant range above the threshold as some firms were eligible based on non-size criteria and other firms may have been incentivized to report themselves as size eligible. We estimate that takeup above the threshold was about 27%.

By scaling up our intent-to-treat estimates to account for the differential take-up rates across the threshold and applying these treatment effect estimates to the population of firms taking up PPP loans, we find that the PPP boosted aggregate U.S. employment by 3.6 million at its peak around mid-May and by 1.4 million at the beginning of December.

We estimate the PPP's cost per job saved under two different scenarios. In the first scenario, we extrapolate the trend decline in the estimated PPP treatment effect to the

point where it reaches zero in mid-June 2021. Integrating over this treatment time, we estimate that PPP expended approximately $257,000 per full-year job retained, which is almost five times the median full-time, full-year U.S. salary in 2020. In the second scenario, we assume instead that the boost to employment from the PPP does not reach zero until the end of 2024 (3.5 years after our data-driven scenario), when the Congressional Budget Office (CBO) currently estimates that the output gap will be closed. Under this generous assumption, which serves as an upper bound on the cost-effectiveness of the PPP program, the estimated cost-per-job-saved by the PPP is $113,000, or twice the median salary.

The high cost per job retained likely reflects the reality that the PPP program was designed to disperse aid as rapidly as possible and hence was not targeted to firms most in need, but rather was available to all small businesses. One consequence was that a large share of PPP dollars appear to have gone to inframarginal firms that would have maintained employment in the absence of the PPP.[1]

Among a number of important caveats to our conclusions, perhaps the most important is that our estimates are properly viewed as local average treatment effects for firms in the vicinity of the eligibility thresholds of 500 or greater. It is possible that the PPP boosted employment at small firms by more than it did for large firms—e.g. because small firms are more liquidity constrained. If so, our aggregate employment estimates will understate the effect of the program. Another important caveat is that we offer only a partial evaluation of the PPP that focuses on employment retention. A complete evaluation would include a broader set of outcomes, including business survival, loan delinquency, and potential general equilibrium effects on the broader macroeconomy (Hubbard and Strain, 2020). That said, our data are uniquely well suited to studying firm-level employment consequences, and this is where we focus.

Our research is most closely related to the contemporaneous working paper by Chetty et al. (2020). These authors use the eligibility size threshold to identify the effect of the

[1]Corroborating this view, Granja et al. (2020) document that there is essentially no geographic correlation between the pre-PPP pandemic economic shock and PPP participation.

PPP program on employment, as we do here. They conclude that employment was boosted by 2 percent at PPP-eligible firms through August of 2020—broadly in line with the effects found here—although their estimates are imprecise and cannot be distinguished from zero. Hubbard and Strain (2020) also assess the employment effects of the PPP using a variety of approaches, including the threshold eligibility design. Their preferred estimates indicate a peak employment effect of about $3\frac{1}{2}$ percent. Although these estimates are similar in magnitude to ours, we note that they rely on comparing extremely small firms to extremely large firms and therefore require rather strong assumptions to be interpreted causally; moreover, in some instances these estimates achieve identification through the endogenous choice to take up a PPP loan.[2]

Distinct from our threshold eligibility approach for identification, a number of recent papers have examined PPP employment effects by comparing firms receiving a PPP loan early in the program period to firms receiving loans later, often exploiting variation in timing due to the varying tendency of local banks to quickly issue PPP loans. We view this timing approach as complementary to our threshold eligibility approach since each strategy has distinct strengths and weaknesses. The timing approach permits directly analyzing the effect of the PPP on smaller firms—a clear benefit given that a majority of PPP loans went to firms well below the 500 employee eligibility threshold. Conversely, our threshold approach identifies the effect of the PPP using a fixed, pre-COVID firm characteristic—firm size. Arguably, this approach requires weaker identifying assumptions than do the timing approaches. Moreover, the threshold approach is well suited to examining the dynamic effect of the PPP over the full course of 2020. In contrast, the timing approach is best suited to examining the employment effects of the PPP in the early months of the program. By mid-2020, however, most small businesses had taken up the PPP, and from this point forward, the timing approach cannot provide a clean contrast between firms with and without a PPP

[2]See their Table 4, columns (4) and (6), and Figures 3a and 3b. Their estimates most similar in spirit to those in this paper, which compare eligible firms sized 400-475 to ineligible firms sized 525-600, indicate the PPP had no effect on employment (see their Table 4, column 5).

loan.

Papers using the timing approach have come to a range of PPP employment effect estimates. Granja et al. (2020) estimate employment effects generally quite similar in magnitude to those found here. In contrast, the results in Li and Strahan (2020) imply a much smaller boost to employment. The results in Doniger and Kay (2021) and Faulkender et al. (2020), though, suggest a substantially larger employment effect than found in this paper.

Finally, using state-level variation in PPP loan receipt, Bartik et al. (2020a) find evidence that the program boosted employment. As these authors stress, though, these findings leave open the question of causality since state-level PPP take-up may in part be driven by state-level economic conditions.

2 The Paycheck Protection Program

The beginning of the pandemic left many small businesses in a precarious financial position and many shuttered operations all together (e.g. Bartik et al., 2020a,b). Anticipating further widespread hardship, Congress introduced the PPP to provide forgivable loans to support ongoing employment. The program was administered by the SBA, with commercial banks playing an important intermediating role by handling the loan application process and loan disbursal (e.g. Granja et al., 2020; Li and Strahan, 2020).

The PPP was established through the CARES Act, passed on March 27, 2020. The first PPP loan was approved on April 3, 2020 and funding was exhausted on April 16. Congress then provided a second tranche of funding and loan approval resumed on April 27. The second round of loans concluded in early August without exhausting the available funding, indicating the program was eventually able to meet available demand. A third tranche of funding enabled a resumption in PPP lending in early January. Unlike loans from the first two tranches, however, most third tranche PPP loans required businesses to demonstrate a significant revenue loss. As our data lack revenue information, we analyze only the first

two tranches of PPP loans, and all subsequent discussion pertains to the first two tranches unless otherwise noted. The complex rules governing the program were altered over time by Congress. Our discussion here focuses on the final rules applying to the first two tranches. See Appendix A for additional details on the PPP program rules and parameters.

PPP eligibility required a firm to meet the SBA's small business size standard, which is defined as 500 or fewer employees on average over a year for the large majority of industries, although the threshold is larger for some industries.[3] Businesses were permitted to draw loans worth up to 10 weeks of payroll costs, with a maximum size of $10 million dollars. Payroll costs include wage and salary compensation of all workers up to an annual rate of $100,000, as well as paid leave, health insurance costs, other benefit costs, and state and local taxes.

PPP loans were entirely forgiven if the loan-receiving firm met several criteria over the 24-weeks following loan disbursement. First, the business's average full-time equivalent employment could not fall below its pre-crisis level. Second, payroll expenses had to equal at least 60 percent of the loan amount. Third, total qualifying expenses—which included payroll expenses, utilities, rent, and mortgage payments—had to at least equal the loan amount. Fourth, wages had to be maintained at not less than 75 percent of their pre-crisis level. If one or more of these criteria were not met, loans could still be partially forgiven.

Despite some initial confusion about these criteria, it is likely that firms anticipated a high degree of loan forgiveness. For example, even firms with significant staffing reductions could in many cases meet the maintenance of employment requirement because the requirement to spend 60 percent of the loan on payroll was measured over a 24 week window, whereas the loan size was equal to 10 weeks of payroll expenses. Indeed, loan forgiveness appears to be nearly universal thus far: currently, out of $280 billion worth of loan forgiveness applications processed, the SBA has declined only $1 billion (Small Business Administration, 2021).

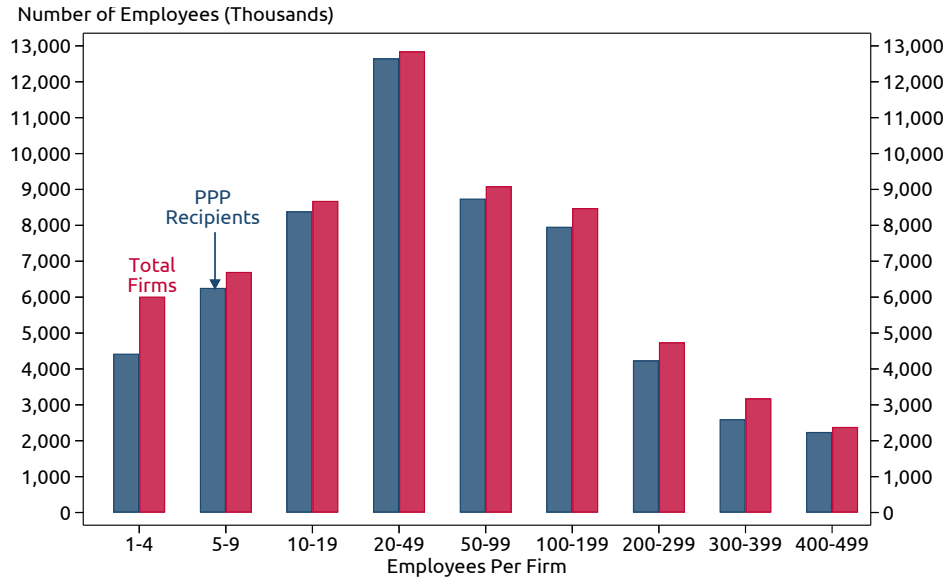
The attractiveness of the PPP loans led to substantial take-up among eligible firms.

[3]Businesses can also qualify for the PPP if their annual receipts or profits are lower than a given threshold. Because we lack access to firm financial data, we are not able to leverage this alternative revenue cutoff.

About 5.2 million PPP loans were approved in 2020 worth around $525 billion, which is about equal to 10 weeks of total payroll (the maximum permitted loan amount in most cases) for *all businesses* with fewer than 500 employees.[4] See appendix B for more details.

Figure 1 shows the number of employees by firm size that received PPP loans, each compared to the Census Bureau's *Statistics of U.S. Businesses* (SUSB) data for 2017 for firms with between 1 and 499 workers. Employment-weighted take-up—defined as the ratio of the blue bars to the red bars—was high across the size distribution, averaging 92.6%. Appendix C provides additional information.

Figure 1: Distribution of PPP Loans by Firm Size, 1-499



Note: PPP loans with positive jobs supported and excluding about 850,000 loans to the self-employed, sole proprietors, independent contractors, single-member LLCs with only one reported job supported since non-employers are excluded from the SUSB universe. Source: Authors' analysis of SBA loan-level PPP data; Census Bureau *Statistics of U.S. Businesses*.

3 A Preliminary Look at the Data

Our analysis harnesses anonymized and aggregated payroll data from ADP, which processes payrolls for over 26 million individual workers in the United States per month. Our analytic data source is a panel of firm-week observations, covering the weeks from February 2, 2020

[4]See Decker et al. (2021) for a detailed analysis of the set of entities potentially eligible for the PPP.

through December 5, 2020 inclusive. Workers at each firm are considered to be employed for the duration of the employer-specific pay period as long as they received any payment. This is the employment concept used by the Bureau of Labor Statistics' Current Employment Statistics (CES). If a firm stops appearing in the ADP payroll data, this could mean that the firm has permanently shut down, that it has temporarily suspended operations, or that it has continued operations without ADP's payroll services. We treat these sample exits as closures, meaning that we set employment to zero for firms that exit the sample for any reason. Though there is turnover in ADP's clientele, we do not expect this to be correlated with PPP treatment eligibility except through the effect of PPP loans on firm exit.

The representativeness of the ADP data has been carefully documented in earlier work by Cajner et al. (2018), Grigsby et al. (2019), and Cajner et al. (2020a). Particularly relevant for this paper, Cajner et al. (2020b) show that employment indexes derived from the ADP data have closely matched the dynamics of the Bureau of Labor Statistics' monthly CES data since the beginning of the pandemic-induced recession. See appendix F for additional discussion.

Firms are eligible for PPP loans if their employment is either less than 500 or less than an SBA-specific size threshold (not less than 500).[5] Our methodology will exploit this threshold rule to contrast employment outcomes at firms that are above versus below the SBA's industry-specific employment thresholds. Because virtually all firms in accommodation and food service (NAICS 72) were likely eligible for PPP loans—and we therefore lack an eligibility threshold with which to estimate an effect of the program—we omit that sector here and in all subsequent analysis.

To provide a preliminary look at the data, Figure 2 plots the evolution of firm-level employment by PPP eligibility. The top panel plots employment indexed to a firm's average level of employment in February 2020 for two size classes: 251-500 (in blue) and 501-750 (in red). Employment declines symmetrically across firm size through the beginning of the crisis,

[5]Firms in industries with higher thresholds than 500 are excluded here but reintroduced in the regression analysis below.

falling by about 11 percent in both size classes by the beginning of April. Once the PPP is in operation, however, the trajectories of these firms diverge, with employment stabilizing more quickly in the firms that would likely be eligible for the PPP. Around two months after the launch of the PPP, employment is approximately 2 percent higher at firms that are likely eligible for PPP loans than at those that are not. From the end of May forward, average employment among firms in these two coarse size bins gradually converges, with the difference falling to about 1 percent by the beginning of July and disappearing by the beginning of September.

The bottom panel of Figure 2 provides additional detail by plotting the evolution of employment and firms further away from the PPP eligibility threshold. These results broadly reinforce the pattern seen in the first panel: employment at firms with between 101-250 employees rises by roughly 2 percent from the time of PPP enactment to the end of June 2020 relative to firms with 500–750 employees. After that time, the difference between these two size groups contracts and is no longer evident by September of 2020.

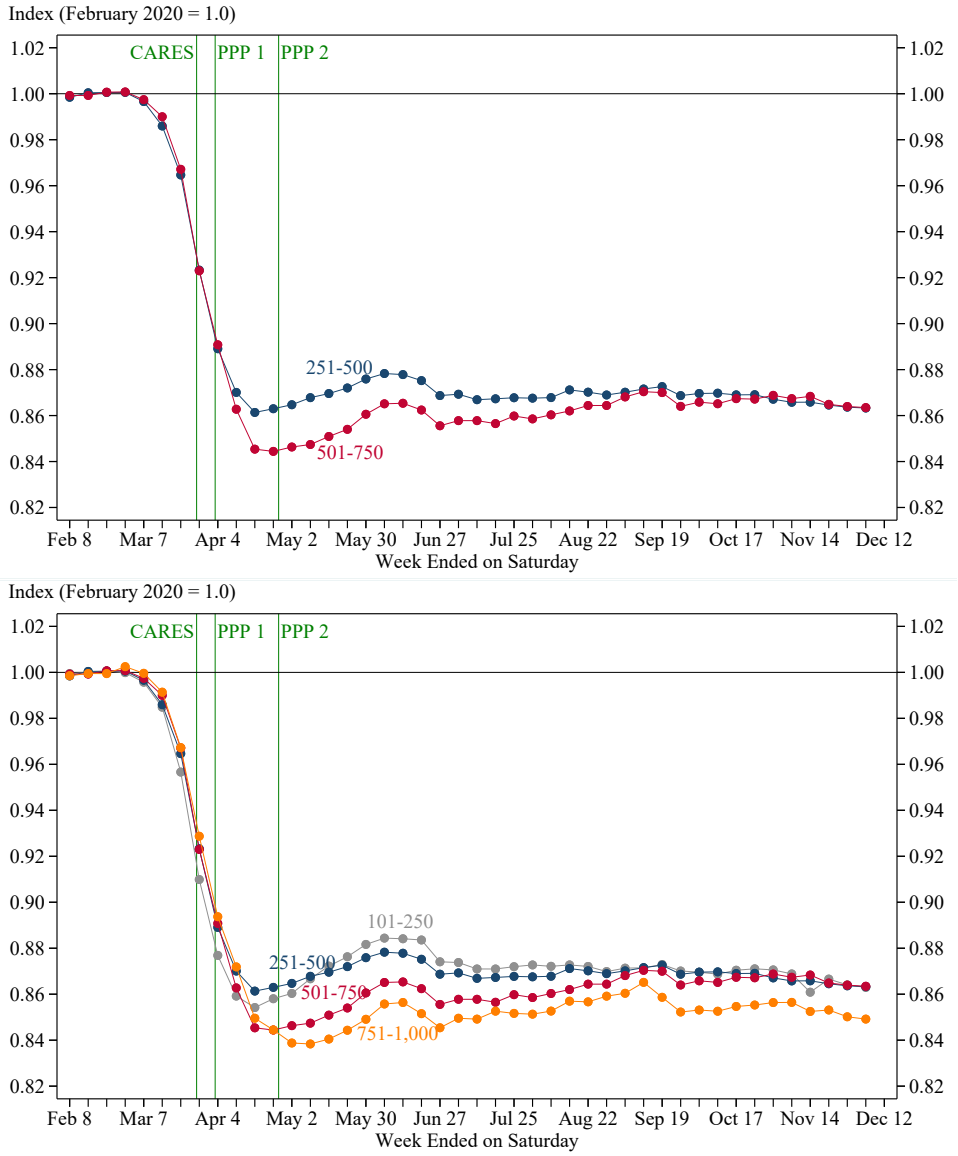
These simple figures suggest that the PPP temporarily boosted employment at firms that were eligible to receive loans compared to those that were primarily ineligible. Our subsequent analyses formally test these relationships.

4 Identification Approach and Primary Estimates

Our empirical strategy exploits the PPP eligibility size thresholds to identify the effect of the program on employment. In the spirit of Figure 2, we compare the outcomes of firms above and below the industry-specific eligibility threshold using a dynamic, difference-in-difference (DD) approach.

A practical challenge to implementing our research design is accurately assigning firms to PPP eligibility status. The PPP allows firms flexibility in choosing a window over which to define average employment for the purposes of meeting the threshold, including calendar

Figure 2: Employment by Firm Size for Industries With PPP Eligibility at 500 Workers



Note: Each series represents average employment for firms with that particular range of workers in both 2019 and February 2020. Data are weighted by each firm's employment as of February 2020. Sample reflects firms that were present in the ADP data for all 12 months of 2019.
Source: Authors' analysis of ADP data.

year 2019, the trailing 12-month average prior to application, or various 12-week periods for seasonal firms. We do not observe the precise data or rule chosen by firms to establish their eligibility. In order to limit the potential for spurious eligibility assignment, we define eligibility based on *both* average 2019 employment and February 2020 employment and omit from the estimation sample firms whose PPP eligibility status differs across these two firm

size measures. In Appendix G, we apply alternative windows for calculating eligibility, and our results are broadly similar to our baseline results.[6]

We use the following dynamic difference-in-difference specification to estimate the relationship between PPP eligibility and employment:

$$y_{ijst} = \alpha + \lambda PPP_i + \theta_{jt} + \theta_{st} + \sum_{t \in T} \beta_t (PPP_i \times \theta_t) + \varepsilon_{ijst} \tag{1}$$

where y_{ijst} is total employment for firm i at week t indexed to equal 1 in February of 2020, θ_{jt} is a vector of NAICS 3-digit industry j–by–week t fixed effects, θ_{st} is a set of state s–by–week t fixed effects, θ_t is a vector of indicator variables for week t, and PPP_i is an indicator variable equaling one if firm i is eligible for the PPP program based on the industry-specific size threshold. Week t spans the period from the week of February 2$^{\text{nd}}$ through February 8$^{\text{th}}$ to the week of November 29$^{\text{th}}$ through December 5$^{\text{th}}$ (i.e., $T = \{2/2, 2/9, ..., 12/5\}$)—covering the period prior to the crisis, the passage of the CARES Act (March 27$^{\text{th}}$), and through most of 2020. Standard errors are conservatively clustered at the NAICS 3-digit industry level. Finally, we weight the regressions by firm size in February 2020 such that the results can be interpreted as the effect of the PPP on the average worker (rather than employment at the average firm).

The time-varying β_t vector is the parameter of interest; under our identifying assumption, it traces out the treatment effect of PPP eligibility. The treatment effect is likely to vary over time for several reasons: receipt of PPP loans gradually ramps up over the period we examine; it may take time for firms to bring workers back onto payroll; and ineligible firms may rebound even absent PPP support as the recovery takes hold. The 3-digit industry-week fixed effects in the model absorb time-varying shocks common to firms within a given

[6] One issue that could lead to spurious inference is mean reversion in firm size. For example, short-term fluctuations in employment around the eligibility-threshold could be inversely correlated with employment growth over the estimation period, and thereby produce upward bias in our estimated treatment effects of the PPP. By defining firm size based on 2019 average employment *and* February 2020 employment we reduce the likelihood of this pitfall as short-term employment fluctuations will tend to average out over longer periods of time.

industry, while state-week fixed effects absorb time-varying shocks common to all firms in a state. Both set of fixed effects are important because industries were affected differently by the pandemic and because states imposed different social distancing rules, did so at different times, and may have experienced different degrees of voluntary social distancing. Equation (1) is heavily saturated as it contains week-specific fixed effects for both the 50 states and the District of Columbia, as well as roughly 100 3-digit industries.

The identifying assumption of the model is that, absent the PPP, firms below the size-eligibility threshold would have experienced comparable employment growth or contraction to firms above the threshold, conditional on the covariates. Underlying trends in firm employment not due to the PPP, particularly those induced by social distancing and the broader economic downturn, are the most likely violation of this assumption. We address these potential violations of the identifying assumption in three principal ways. First, the pre-CARES Act portion of the β_t vector provides a partial check against differential employment trends correlated with PPP eligibility. If PPP eligibility is not confounded with underlying trends, there should be no trend in the β_t vector in the pre-CARES Act period. Second, as discussed above, the inclusion of industry-week and state-week fixed effects controls for time-varying shocks associated with COVID-19 at both the industry and state level. Third, in order to render the treatment and control groups as comparable as possible, we limit the estimation sample to firms in various windows around the threshold, from between 50 to 250 workers.

As an initial check on the comparability of firms above and below the eligibility threshold, Table displays 1 firm summary statistics. These comparisons show that, apart from size, firms above and below the eligibility threshold appear quite comparable prior to the crisis, as measured by gender composition, weekly hours worked, weekly earnings per worker, weekly wage per worker, and employment distribution across broad sectors.

Figure 3 reports our main estimates of equation (1). Each panel presents estimates of the β_t vector for a different firm size window—e.g. the top-left panel shows the results for a window of 250 employees above and below the SBA's industry-specific eligibility threshold.

Table 1: Summary Statistics as of February 2020

	PPP Threshold ±250		PPP Threshold ±100	
	0-249 Below	1-250 Above	0-99 Below	1-100 Above
Employment	389.8	653.4	472.9	579.1
% Female	46.2	46.4	46.1	48.5
% Hourly	62.5	64.1	63.0	63.0
Weekly Hours Per Worker	36.8	37.4	37.3	37.2
Weekly Earnings Per Worker ($)	1,271.8	1,277.3	1,278.6	1,278.8
Hourly Wage Per Worker ($)	37.8	36.9	37.7	37.5
Sectors (%):				
Manufacturing	7.8	9.0	8.7	8.2
Wholesale Trade	8.2	9.0	8.1	10.4
Retail Trade	6.4	8.1	6.2	8.4
Financial Activities	9.1	9.1	9.3	8.0
Professional & Business	17.4	17.0	17.2	15.9
Education & Health	18.9	17.9	20.2	18.3
Leisure & Hospitality	6.6	6.9	6.4	6.7
Other	25.7	22.9	24.0	24.2

Note: Employment, weekly hours, weekly earnings, and hourly wage represent firm-level means for each column. Data are weighted by each firm's employment as of February 2020. Samples reflect firms that were present in the ADP data for all 12 months of 2019.
Source: Authors' analysis of ADP data.

The shaded region in each panel corresponds to the 95 percent confidence interval around the point estimates.

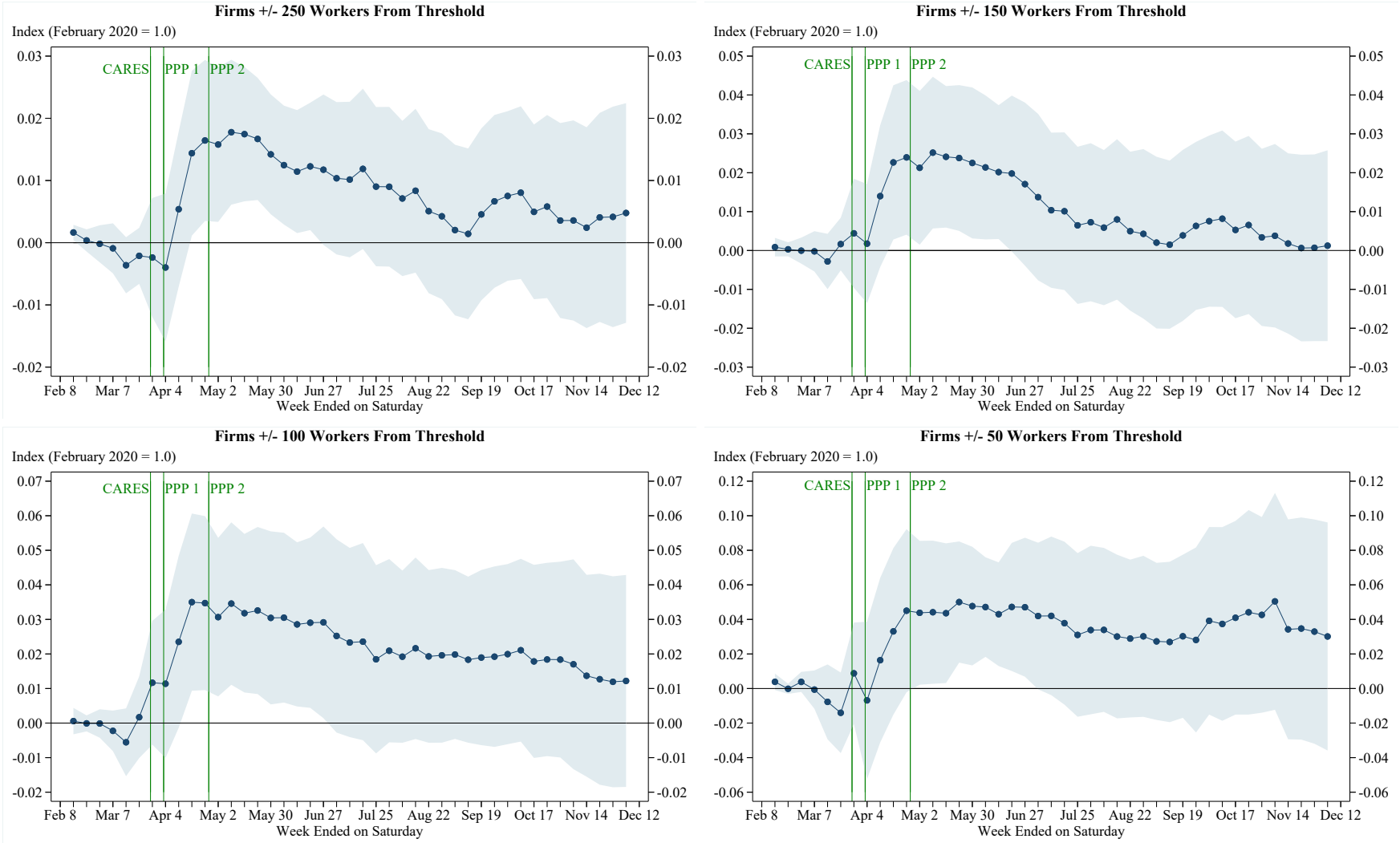
The results uniformly show a positive treatment effect of PPP eligibility on firm employment. Starting with the top-left panel, employment at firms with up to 250 employees below the eligibility threshold trends in parallel with employment at firms with up to 250 employees above the eligibility threshold prior to PPP, with pre-trend point estimates consistently around zero. Once the PPP commences in the first week of April 2020, employment moves relatively higher at eligible firms, rising by about 2 percent through May, after which time, this gap attenuates. The contrast is no longer statistically significant after the beginning of July, though the point estimates suggest that employment at eligible firms was about 1 percent higher than at ineligible firms in July and roughly 0.5 percent higher on average thereafter.

The estimates presented in the other panels of Figure 3 for different size windows around the eligibility threshold are qualitatively similar to those in the first panel. The peak point

estimates become slightly larger, however, as the size window shrinks. In the top-right panel in Figure 3, which includes firms within 150 employees of the eligibility threshold, the peak employment effect is roughly 2.5 percent. The peak response rises to nearly 3.5 percent and 5 percent for the firms within 100 and 50 employees of the eligibility criteria, respectively, shown in the bottom-left and bottom-right of the figure. Averaging across all four specifications, the peak effect registers at about 3 percent in mid-May.

From mid-May forward, the point estimates decline to different degrees throughout 2020. At the end of the year, the point estimates range from no effect (for the $\pm$ 150 window) to about 3 percent (for the $\pm$ 50 window). Across the four specification, the point estimate averages about 1.2 percent at the end of 2020.

Figure 3: Effect of PPP Eligibility on Employment



Note: Each firm's size is determined using employment in both 2019 and February 2020. Regressions are weighted by firm size as of February 2020 and include controls for state-by-week and industry-by-week effects. Standard errors are clustered at the 3-digit NAICS industry level. Sample reflects firms that were present in the ADP data for all 12 months of 2019.
Source: Authors' analysis of ADP data.

Employment in treatment and control groups was trending in parallel in the pre-PPP period but not thereafter, as shown in Figure 3, consistent with a causal interpretation of the treatment effect estimates . That said, one anomaly visible is that when focusing on firms with employees within 100 of the eligibility threshold (bottom-left panel) the treatment effect appears to commence *during* the week of the passage of the CARES Act. This may reflect anticipation of PPP implementation. The CARES Act was passed by the Senate on March 25 and passed by the House and signed into law on March 27. In the week prior to its passage by the Senate, there was widespread anticipation of, and reporting on, an SBA loan program for small businesses under 500 employees.[7] It is therefore possible that business owners below the threshold held off paring back on payrolls in anticipation of the loan program. There is also a clear jump upward in the treatment effect vector after PPP loans commence. This pre-treatment jump using the ±100 employee size window is the one anomalous finding in our analysis, and we flag it for the sake of caution.

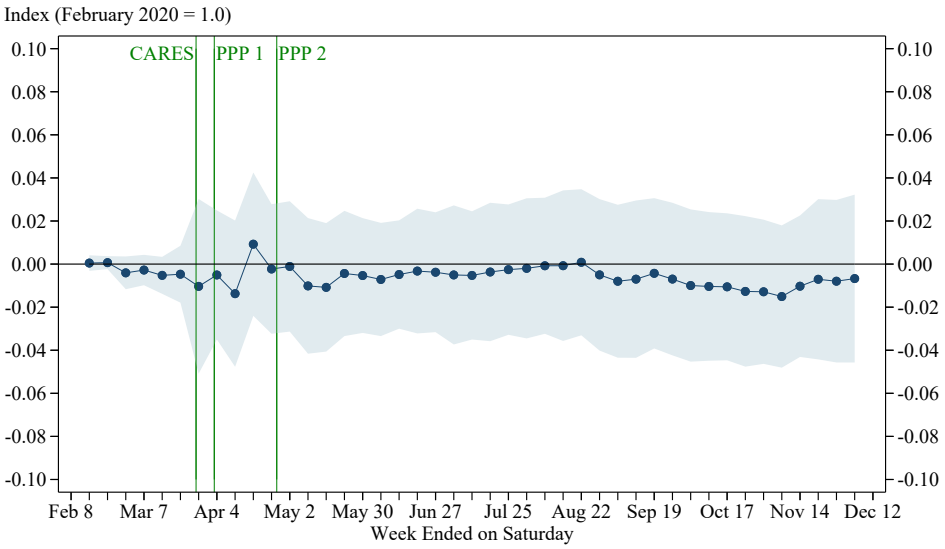
Figure 4 offers a reality check on our identification strategy. Although in most sectors, PPP eligibility was limited to firms with 500 or fewer employers, the size cap was higher in specific sectors, and we would not expect to find a "treatment effect" at the 500 threshold in these sectors. To verify this implication, we estimate equation (1) for firms in high-threshold industries, using firms of size 251 to 500 employees as the placebo treatment group and firms of size 501 to 750 serve as the comparison group. (The minimum actual PPP eligibility threshold for firms with a non-500 threshold is 750.) Figure 4 confirms that the placebo treatment effect is estimated to be near zero in both the pre- and post-PPP period.

5 Estimating Treatment-on-the-Treated

Our primary results shown in Figure 3 are intent-to-treat (ITT) estimates, reflecting the effect of loan *eligibility* rather than loan *take-up* on employment. To estimate the effect of

[7] For example, both a *Washington Post* article on March 18th and a tweet from Senator Marco Rubio on March 17th discuss the 500 firm size threshold.

Figure 4: Placebo Effect of Having 251-500 Workers on Employment for Firms With PPP Eligibility Above 500



Note: Each firm's size is determined using employment in both 2019 and February 2020. Regressions are weighted by firm size as of February 2020 and include controls for state-by-week and industry-by-week effects. Standard errors are clustered at the 3-digit NAICS industry level. The sample is restricted to firms with a PPP eligibility threshold above 500 and with 251 to 750 employees; those sized 251 to 500 form the placebo treatment group and those sized 501 to 750 form the control group. The sample contains only firms that were present in the ADP data for all 12 months of 2019.
Source: Authors' analysis of ADP data.

receiving a PPP loan—i.e. the average effect of treatment-on-the-treated (ATT)—we re-scale the ITT estimates, β_t, using the standard Wald estimator:[8]

$$\delta_t = \frac{\beta_t}{\underline{\gamma} - \overline{\gamma}}. \tag{2}$$

where $\underline{\gamma}$ is PPP take-up among those firms below the SBA size threshold and $\overline{\gamma}$ is take-up among firms above the threshold.

Firms above the eligibility threshold may have been able to take out a PPP loan for at least two reasons. First, firms that had sufficiently small revenues or profits were entitled to PPP loans, despite potentially having more than 500 workers.[9] Second, firms' self-reported employment was not verified at the time of application (or subsequently, to our knowledge), so PPP loan applicants had some leeway in determining their own eligibility.

[8]For the sake of simplicity, we use the terminal take-up rates; hence the γ's are time-invariant.
[9]As noted above, our data lack the financial information required to calculate eligibility on this basis.

Since our primary data source does not record PPP loan receipt, we estimate take-up using SBA loan-level PPP records. Unfortunately, the employment size of recipient firms in this SBA loan data is truncated at 500 workers, meaning that for industries with eligibility thresholds above 500 employees, we cannot estimate take-up *below* the industry-specific threshold, $\underline{\gamma}$. For the same reason, across all industries, we cannot directly estimate the take-up above the threshold, $\overline{\gamma}$.

We address these limitations as follows. To estimate take-up below the threshold, we restrict attention to industries with a 500 worker threshold and assume the estimated take-up rates from this subset of industries holds across all industries. Specifically, using publicly-available Census SUSB data reporting firm size by industry paired with SBA PPP loan-level data, we estimate that $\underline{\gamma} \approx 81\%$ within a firm size window of 300-499 employees. Next, to estimate take-up above the eligibility threshold, $\overline{\gamma}$, we again restrict attention to industries with a 500 worker threshold and assume that firms coded (i.e., truncated) at size 500 in the PPP loan-level data are drawn from the size range 500-999 and are the same size on average as firms in that size bin in the SUSB data. This yields an estimate of $\overline{\gamma} \approx 27\%$, and a denominator for equation (2) of $\underline{\gamma} - \overline{\gamma} = 54\%$.

Adjusting for take-up above and below the threshold yields an ATT estimate of $\delta_t = \frac{1}{\underline{\gamma}-\overline{\gamma}} * \beta_t = \frac{1}{0.81-0.27} * \beta_t = 1.85 * \beta_t$. In practice, different firm size bins above and below the eligibility threshold produce slightly different inflation factors, $\frac{1}{\underline{\gamma}-\overline{\gamma}}$. In the aggregate employment effect calculations below, we set $\frac{1}{\underline{\gamma}-\overline{\gamma}}$ equal to its average value of 2 across a set of such estimates. See Appendix C for details, including Figure C.1 which presents estimates of the ATT. This appendix also contains additional discussion of our PPP take-up rate estimates and corresponding treatment-on-the-treated inflation factors, including a comparison to similar calculations in Chetty et al. (2020).

6 Estimating the Aggregate Employment Effect of the PPP

With an estimate of the employment effect of receiving a PPP loan in hand, it is straightforward to estimate the implied effect of the PPP on total U.S. payroll employment:

$$E_t = \delta_t \times T \tag{3}$$

where δ_t is the ATT estimate and T is the number of employees at *PPP-recipient* firms. We estimate $T = 59.2$ million using our estimated take-up rates multiplied by the count of employment below industry-specific eligibility thresholds, *plus* PPP take-up above 500, which we again assume is drawn from the 500-999 firm-size bin. See Appendix D for additional details.

At its peak around mid-May, averaging across the specifications in the Figure 3, PPP loan receipt raised recipient employment by about 6% (3% average intent-to-treat estimate times the scaling factor of 2), yielding an estimated employment gain of about 3.6 million workers in total (6% $\times$ 59.2 million). By the beginning of December, the ATT estimates are uniformly smaller, averaging 2.4%, implying an employment delta of about 1.4 million.

An important caveat is that these calculations extrapolate from treatment effects that are estimated from firms in the vicinity of the eligibility thresholds. It is possible that the PPP had different effects on firms farther away from the eligibility threshold (i.e., smaller firms). If, for example, smaller firms were relatively more cash constrained during the crisis, PPP funds may have relaxed this constraint, resulting in a larger share of jobs retained. Alternatively, these firms may have been sufficiently vulnerable during the crisis that the PPP was insufficient to keep them operational. Approximately 53% of employment potentially affected by PPP loans was in firms with employment below 50, a reasonable proxy for the group of firms that may have been particularly vulnerable *and* which do not contribute to the

identification of our causal effect estimates. If we assume that the peak effect of loan receipt is twice as large in this group of firms (12%), this increases our estimated peak employment effect from 3.6 million to 5.5 million. Conversely, if we assume that the effect of loan receipt is half as large for these firms, this reduces our peak employment estimate to 2.6 million.

To put these employment numbers in dollar terms, we calculate the cost per year of employment preserved by the PPP. We calculate this cost as: $52 \times \frac{PPP_{volume}}{\sum_{t \in T} E_t}$, where $\sum_{t \in T} E_t$ is the sum of additional weekly employment attributable to the PPP from the beginning of the PPP program through the end of our sample, and PPP_{volume} is the total dollar volume of PPP loans from the first two tranches of the program. This calculation yields a cost of $317,000 per full-year job preserved by the PPP from the program's inception to the start of December of 2020 (the end point of our data set).

A limitation to this calculation is that it implicitly assumes that there is no effect of the PPP on employment after early December. Our point estimates in Figure 3, however, suggest that the impact remains positive in that month, although these estimates are statistically insignificant. We adjust for the effects of PPP on employment after early December 2020 under two plausible scenarios.

The first scenario is data driven and allows the estimated effect of E_t to follow its trend decline observed from mid-May to the end of our sample, implying that the treatment effect reaches zero in the third week of June 2021. Under this assumption, the PPP preserved 1.6 million jobs per week on average from April 2020 through June 2021, implying a program expenditure of $257,000 per full-year-equivalent job preserved.

In the second, forecast-based scenario, we assume the effect of the PPP declines linearly until the GDP output gap closes, which the Congressional Budget Office projects will occur in the fourth quarter of 2024 (CBO, 2021). With the economy operating at its potential output level, there is little scope for the PPP to boost employment. This implies a cost per full-year job preserved of $113,000, which is considerably lower than the prior estimate. This scenario is clearly favorable for the PPP's cost-effectiveness since it assumes that the

program generates 3.5 years of additional employment benefits beyond what is suggested by our estimates. Nonetheless, as the median full-time full-year worker earned about $50,000 in 2020[10], our estimates imply that the cost per job retained was 2.3 times the median worker's salary under these very generous assumptions, and 5.1 times the median salary under more realistic assumptions. See Appendix E for additional information on these scenarios, including a graphical representation in Figure E.1.

7 Conclusion

Utilizing high-resolution administrative microdata on firm-level employment from ADP, we provide an assessment of the PPP's effect on U.S. employment, focusing on the $525 billion in forgivable PPP loans made during 2020, prior to a substantial change in program targeting in 2021. Using a dynamic difference-in-difference framework, we estimate that the PPP increased the level of employment at eligible firms by 2 to 5 percent at its peak in mid-May and slowly declined thereafter. These estimates imply that the PPP preserved approximately 3.6 million jobs in mid-May of 2020, and about 1.4 million jobs at the end of 2020. The estimated dollar amount of PPP expenditure per year of employment preserved ranges from 2.3 to 5.1 times the median full-time full-year U.S. salary in 2020.

While our estimates imply that PPP outlays substantially exceeded the salary costs of jobs supported by the program, we note that a full cost-benefit analysis of the PPP would include additional margins of potential efficacy not evaluated by the current research. By preventing bankruptcies, the PPP may have preserved valuable intangible firm capital, which could have positive long-run economic effects. The PPP may also have reduced loan defaults, which would benefit creditors throughout the economy (e.g. suppliers to businesses and commercial landlords) and also possibly reduce strain on the financial system. Finally, the PPP may have reduced other public outlays that workers would have received had the PPP not

[10]Equal to 52 times median weekly earnings in the first quarter of 2020 of $949 as measured in the Bureau of Labor Statistics' *Usual Weekly Earnings*.

preserved their employment, such as unemployment compensation, rental assistance, Supplemental Nutrition Assistance Program (SNAP) benefits, and other safety-net programs. A full accounting of the numerous indirect avenues of potential PPP program efficacy merits significant additional research.

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Web Appendix

A Details of PPP Program

This appendix section provides additional information on the PPP program and its parameters.

A.1 PPP Timeline

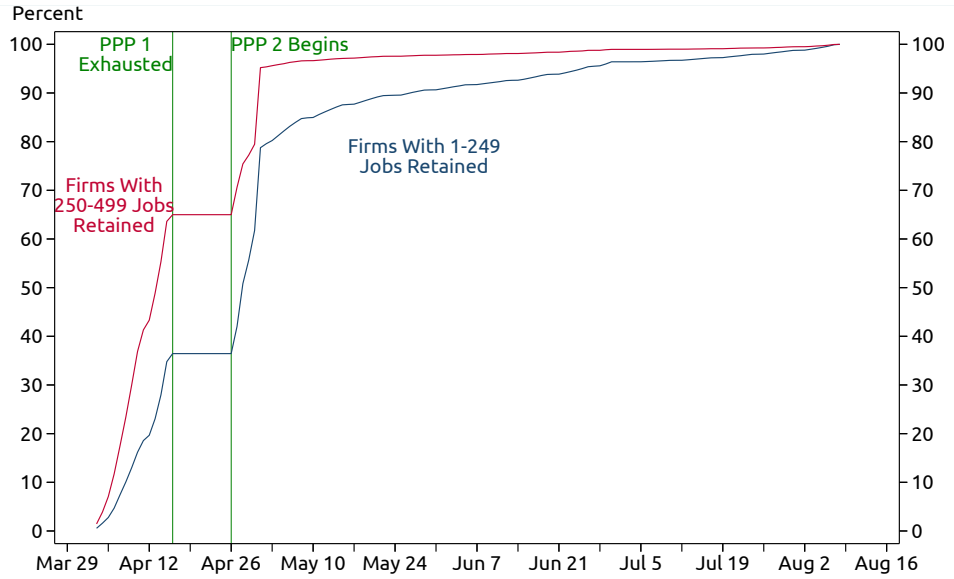
The first tranche of PPP funding was included in the Coronavirus Aid, Relief, and Economic Security (CARES) Act passed on March 27, 2020, and the second tranche was established in the Paycheck Protection Program and Health Care Enhancement Act, which passed on April 24. The third tranche of PPP funding—which we do not analyze in this paper—was provided by the Consolidated Appropriations Act of 2021, passed on December 27, 2020.

The first applications for PPP loans were accepted on April 3rd with funds disbursed within 10 days of final SBA approval.[11] There was strong demand for loans at the beginning of the program with the first tranche of $350 billion exhausted by April 16th and 85% of all loans from the first two tranches approved by the end of the first week of May.

The speed at which loans were granted varied with the size of businesses. Figure A.1 examines the timing of the approvals of these loans by size of the firm. By the middle of April, the SBA had already approved 70 percent of the eventual total number of loans granted to firms between 250 and 499 employees. In contrast, loans to smaller businesses did not reach 70 percent of their eventual total until early May.

[11] Participating lenders were responsible for verifying the applications and passing them onto the SBA for final approval. Originally, some lenders were making an initial partial disbursement within 10 days but not making the full disbursement until later in order to delay the forgiveness criteria reference period. At the end of April, guidance was issued that the full funds must be disbursed within 10 days of the loan being approved.

Figure A.1: Cumulative Distribution of PPP Loan Approvals by Date



Note: Data reflect reported jobs supported and exclude PPP loans to non-employers as well as loans to businesses in Puerto Rico, Virgin Islands, and Guam.
Source: Authors' analysis of SBA loan-level data release.

A.2 PPP Rules

There was initially significant confusion among businesses and analysts over the specifics of the PPP rules for loan forgiveness, which evolved considerably after the passage of the CARES Act. Most notably, the Paycheck Protection Program Flexibility Act, passed on June 4th 2020 but applied retroactively to previously-approved loans, extends the window over which loan proceeds can be spent to qualify for forgiveness from 8 weeks to 24 weeks and reduces the required share of the loan spent on payroll from 75 percent to 60 percent.[12] Many firms received loans well before the Flexibility Act was passed and may have made decisions under the original rules. Alternatively, firms may also have used the more flexible rules to spend additional funds on fixed obligations rather than payrolls, thus reducing the likely employment impact of the PPP.

[12]If borrowers are required to repay a PPP loan, the terms are relatively favorable: The first installment of the loan is deferred for six months and the interest rate is only 1 percent.

B Total Payroll And Employment of U.S. Businesses

The scale of the approximately $525 billion in first and second round PPP loans was about equal to the size of the targeted set of small businesses. Specifically, according to Census Bureau's Statistics of U.S. Business (SUSB) data, 10 weeks of payroll—the metric used to determine PPP loan size in most cases—for *all private-sector businesses with fewer than 500 employees* was about $520 billion in 2017. This figure, though, likely underestimates potential payrolls eligible for the PPP, since in some industries, businesses with more than 500 employees could qualify for PPP loans.

Table B.1: Firms With Fewer Than 500 Employees, 2017

	Firms	Employment	$2\frac{1}{2}$ Months Payroll ($)
Total Private Sector	5,976,761	60,556,081	521,449,419
Agriculture, Forestry & Fishing	22,535	136,591	1,124,746
Mining & Oil & Gas Extraction	18,720	244,367	3,707,711
Construction	700,393	5,373,702	59,522,179
Manufacturing	244,098	5,039,772	47,835,647
Trade, Transportation & Utilities	1,129,034	10,736,588	91,535,076
Information	78,430	984,379	14,433,836
Financial Activities	544,763	3,361,539	45,126,926
Professional & Business	1,170,857	9,368,738	108,232,178
Education & Health	742,837	10,630,121	81,539,312
Leisure & Hospitality	666,730	9,971,192	40,272,986
Other Services	695,268	4,697,878	28,058,288

Source: Census Bureau, *Statistics of U.S. Businesses.*

C Take-up Rates and the Treatment-on-the-Treated Inflation Factor

The take-up scaling adjustment, as defined in equation (2), is equal to $\frac{1}{\underline{\gamma}-\overline{\gamma}}$. We therefore require estimates of the PPP take-up rate both below ($\underline{\gamma}$) and above ($\overline{\gamma}$) the eligibility threshold.

We calculate employment-weighted PPP take-up rates (i.e., number of employees at PPP-

receiving firms relative to total number of employees at all firms) using two data sources. The number of employees at PPP-recipient firms—i.e. the numerator in the take-up rate—is obtained from the "jobs reported" variable in the PPP loan-level data maintained by the SBA. The number of jobs—i.e. the denominator in the calculation—is taken from the Census Bureau's SUSB data.

We restrict the sample to six-digit NAICS industries with PPP eligibility size thresholds of 500 due to the truncation of firm size to 500 in the PPP loan data. We collapse the number of jobs reported in the PPP loan data by the following size bins (determined by the bins available in the SUSB data): 1-4, 5-9, 10-19, 20-49, 50-99, 100-199, 200-299, 300-399, 400-499, and 500. We eliminate loans to businesses in Puerto Rico, the Virgin Islands, and Guam as those are outside of the scope of the SUSB data. We further drop loans to non-employers, defined as sole proprietors, independent contractors, single-member LLCs, and the self-employed with one reported job as they are also out of scope for the SUSB. In addition, we drop loans that are reported as un-disbursed. Finally, we trim (or drop) PPP loans at the bottom and top 1 percentile of the loan-amount-per-job distribution to address outliers.

We utilize the SUSB data cut by firm size bins and six-digit NAICS industries as of 2017Q1—the most recent period of available data. We extrapolate SUSB employment to 2019Q4 using a growth rate calculated from the BLS's *Business Employment Dynamics* (BED) data for the closest relevant firm-size bin.

We calculate employment-weighted PPP take-up rates because the SUSB data count firms in each industry within which they operate, making it impossible to estimate a unique count of firms by size bin. The count of employment by six-digit industry and firm-size bin, though, is available. From these data, we compute total employment counts by size bin across all six-digit industries with PPP eligibility thresholds of 500 to form the denominators of the take-up rates. Some cells at the six-digit level are suppressed in the SUSB data to ensure data confidentiality. To correct for data suppression, we multiply our aforementioned

total employment estimate from aggregated six-digit-industry-by-size cells for industries with 500-worker thresholds by a correction factor. The correction factor is defined as the ratio of published total employment by size bin across all industries divided by total employment aggregated from the six-digit-industry-by-size cell, again across all industries.

For size bins smaller than 500, take-up is calculated simply as the ratio of the number of jobs in the PPP loan data divided by number of employees from SUSB data by firm size bin. To estimate take-up of firms larger than 500 requires further adjustments. We assume that firms are drawn from size bins 500-749 or 500-999 and that the average size of PPP recipients are the same as the average size of firms in those bins at the national level (because we cannot obtain firm-size counts, we cannot calculate average size at the disaggregated industry level). Specifically, for firms at the truncated size of 500 in the PPP loan data and in industries with size thresholds of 500, we impute that firm size is 632 within the 500-749 bin and 742 in the 500-999 bin.[13]

Table C.1 shows take-up rates produced by our methodology. The first column is for industries with size thresholds of 500, which shows an employment-weighted average of 89.9% below 500, and around 81% between 200-499 or 300-499. Take-up is either 38.5% using the 500-749 window or 26.6% using the window 500-999. The second column shows take-up rates omitting our trimming of the PPP loans at the top and bottom percentile of the loan-amount-per-job distribution. This shows similar patterns although somewhat higher take-up rates. Finally, for comparison, the last column shows take-up rates estimated in industries with higher than 500 PPP eligibility thresholds. These take-up rates do not fall off above

[13]As discussed in section 4, firms could calculate their employment in a number of different ways to determine PPP eligibility. Moreover, firms had a clear incentive to report a firm size which would render them eligible. It is therefore possible that many firms reported themselves as having exactly 500 employees in order to obtain eligibility. Such "bunching" in reported firm size at the 500 threshold would be very consistent with similar behavior documented in a wide variety of settings in responses to changes in the intercept of schedules of incentives—see Bertanha et al. (2021) for a discussion of the "bunching" literature. In our calculation of PPP take-up rates, we assume all firms with exactly 500 employees in the loan-level data had more than 500 employees in truth due to the truncation of firm size at 500. Thus, bunching may be a partial explanation for the prevalence of PPP take-up among firms above the eligibility threshold in our calculations. We view this as valid because excessive bunching in firm size at 500 would suggest firms near the threshold, but above it, had a tendency to report exactly 500 employees in order to obtain eligibility. Unfortunately, the truncation of the PPP loan-level employment data prevents assessing this hypothesis.

500 as they do in industries with a eligibility threshold of 500. This pattern supports our placebo falsification exercise in Figure 4. If, conversely, the take-up rate fell off above size 500 in industries with an eligibility threshold above 500, we'd expect to estimate a PPP eligibility effect in the placebo test.

Table C.2 shows the resulting scaling factors from the take-up rates estimated in Table C.1. The different size bins below the eligibility threshold form the rows of the table and the different size bins above the eligibility threshold form the columns. The inflation factors range from 1.6 to 2.4, averaging about 2, the estimate we implement in Section 6 to calculate the aggregate employment effects of the PPP.

Figure C.1 presents our treatment-on-the-treated estimates (ATT) based on averaging across the intent-to-treat estimates on the four panels of Figure 3 for each week of the ADP sample and then multiplied by the average scaling factor of 2.

As noted in the text, Chetty et al. (2020) make calculations similar to those discussed here. Instead of inflating their PPP intent-to-treat estimates by an employment-weighted take-up rate differential, however, these authors use a loan-dollar-per-job differential. Their resulting inflation factor is equal to 1.35. Calculating the equivalent inflation factor in our data yields an inflation factor of about 1.55, somewhat lower than the estimates implied by the employment-weighted take-up rates presented here.

D Estimate of PPP-Recipient Employment

In order to calculate the aggregate employment effect of the PPP, E_t, we require an estimate of the number of employees at PPP-recipient firms, T; see equation 3. Because of the variation in PPP-eligibility thresholds across industries, as well as take-up above 500, the calculation requires several data points from the SUSB employment data (corrected to account for employment growth from 2017Q1-2019Q4 and for data suppression as discussed above in Appendix C).

Table C.1: PPP Take-up by Firm Size (%)

Firm Size	Take-up Rate	Take-up Rate No trimming	Take-up Rate >500 thresholds
1-4	72.5	73.7	70.0
5-9	92.9	94.1	87.0
10-19	96.9	98.4	89.0
20-49	99.0	101.4	89.3
50-99	94.7	98.9	85.5
100-199	88.1	94.6	86.0
200-299	81.2	87.6	89.6
300-399	75.4	81.7	75.2
400-499	87.8	94.3	87.2
500-749	38.5	50.2	109.0
500-999	26.6	34.6	74.9
Additional Statistics:			
1-499	89.9	93.4	86.5
200-499	80.9	87.4	84.4
300-499	80.7	87.1	80.4

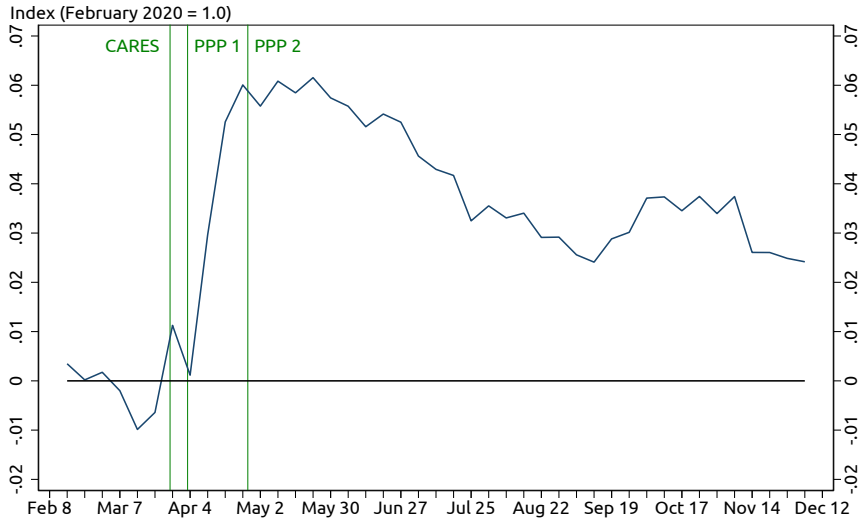
Note: Census Bureau, *Statistics of U.S. Businesses*, SBA PPP, and BLS BED.

Table C.2: Scaling Factors

	500-749	500-999
200-499	2.4	1.8
300-499	2.4	1.8
400-499	2.0	1.6

Note: Census Bureau, *Statistics of U.S. Businesses*, SBA PPP, and BLS BED.

Figure C.1: Average Treatment-on-the-Treated Coefficients



Note: The coefficients shown here are averaged across the four panels of Figure 3 for each week of the ADP sample and then multiplied by an inflation factor of 2. See the note on Figure 3 for details on the specification.
Source: Authors' analysis of ADP data.

First, we calculate total employment across all industries below their respective PPP-eligibility thresholds. Because the SUSB data do not provide employment in the size bin 1,000 - 1,250 but rather for the bin 1,000-1,499, for industries with 1,250 worker thresholds we must add up all employment below 1,000 plus half of employment between 1,000-1,499. Additionally, we include all employment in NAICS 72 (as virtually all such employment was PPP eligible). All together, we estimate that 64.1 million employees were at firms under PPP eligibility thresholds. We multiply this by our estimate of take-up of 89.9% for firms sized 1-499—see Appendix Table C.1—to find 57.6 million employees were at PPP-recipient firms under the industry-specific PPP eligibility thresholds.

Finally, we include employees at firms above the size threshold of 500 using our assumption that these firms were drawn from the bin 500-999. In total, this represents 5.7 million employees. Multiplying this by the take-up rate for firms between 500-999 of 26.6%, we find there were 1.5 million employees at PPP-receiving firms above the size threshold of 500.

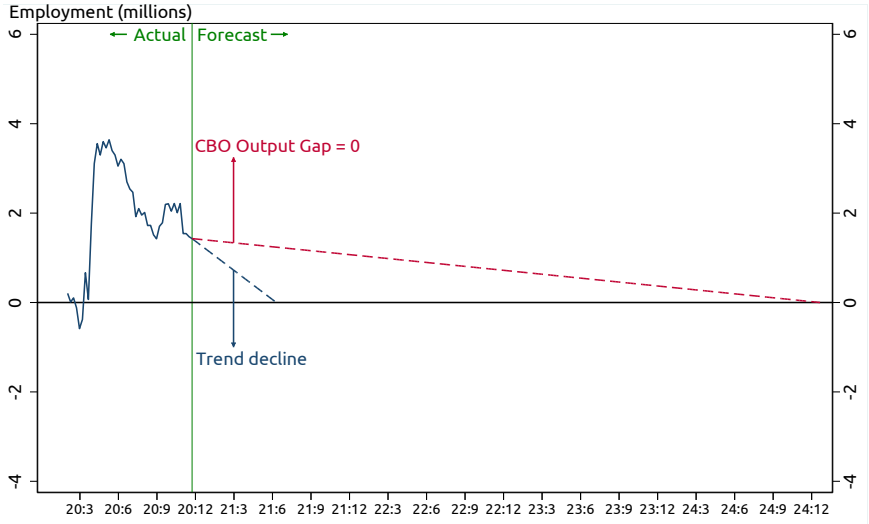
In total, we estimate that there 59.2 million workers at firms that received PPP loans. To provide a benchmark for this number, we calculate the total number of workers reported in the PPP loan-level data, assuming that those firms reporting 500 workers are on average the size of firms with 500-999 workers. Such a calculation yields 61.6 million workers at PPP receiving firms, which is within 4% of our estimate using the SUSB data.

E Aggregate Employment Effect Scenarios

Figure E.1 displays the estimated aggregate employment effect of the PPP according to the methodology explained in Section 6. The blue dashed line ("Trend decline") presents the scenario in which the employment effect continues to decline according to its estimated trend from mid-May to the end of the sample period in early December. The red dashed line ("CBO Output Gap = 0") presents the scenario in which the employment effect decays linearly from the beginning of December to December of 2024 when the CBO projects the

output gap will equal zero.

Figure E.1: Aggregate Employment Effect Scenarios



Note: The estimates shown here are calculated according to the methodology explained in Section 6.
Source: Authors' analysis of ADP data.

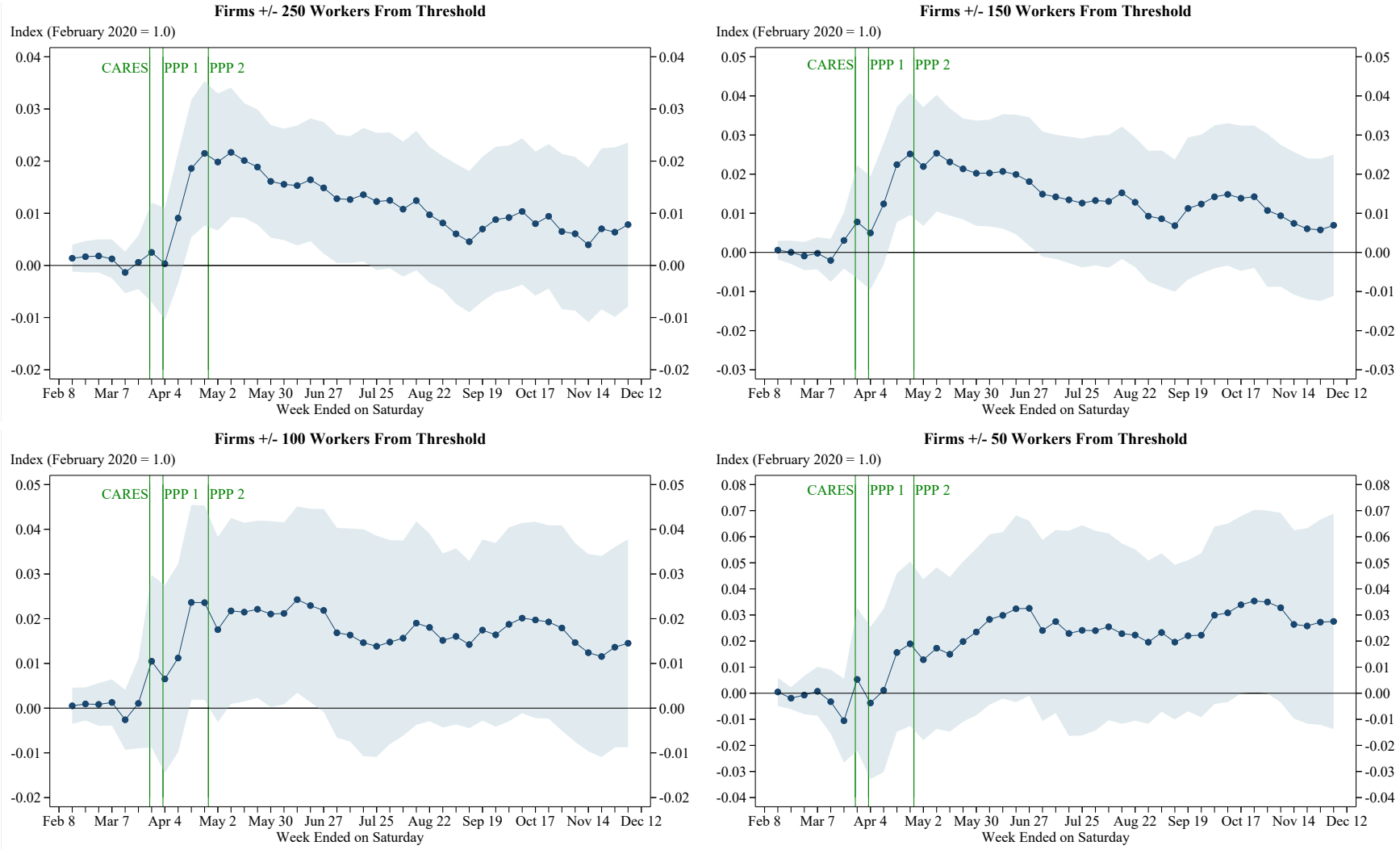
F Representativeness of the ADP data

The ADP data used in this paper is organized as a linked employer-employee panel. (For analysis purposes in this paper, the data is reformed into a panel of firm-week observations.) The representativeness of this ADP data has been documented carefully in the literature. Grigsby et al. (2019) show that the ADP data are broadly representative with respect to firm size, average wage level, demographics of workers, hourly versus salaried status, and frequency of pay. Cajner et al. (2020a) and Cajner et al. (2018) show that a closely-related firm-level dataset from ADP is also broadly representative with respect to industry composition, firm size, and geography, and, additionally, that the aggregate employment dynamics in the ADP data mirror the business cycle-frequency dynamics in the official data over the Great Recession and the subsequent recovery. Cajner et al. (2020b) show that indexes derived from the ADP data have closely matched the dynamics of the Bureau of Labor Statistics' monthly CES data since the onset of the pandemic-induced recession.

G Eligibility Definition Robustness Analysis

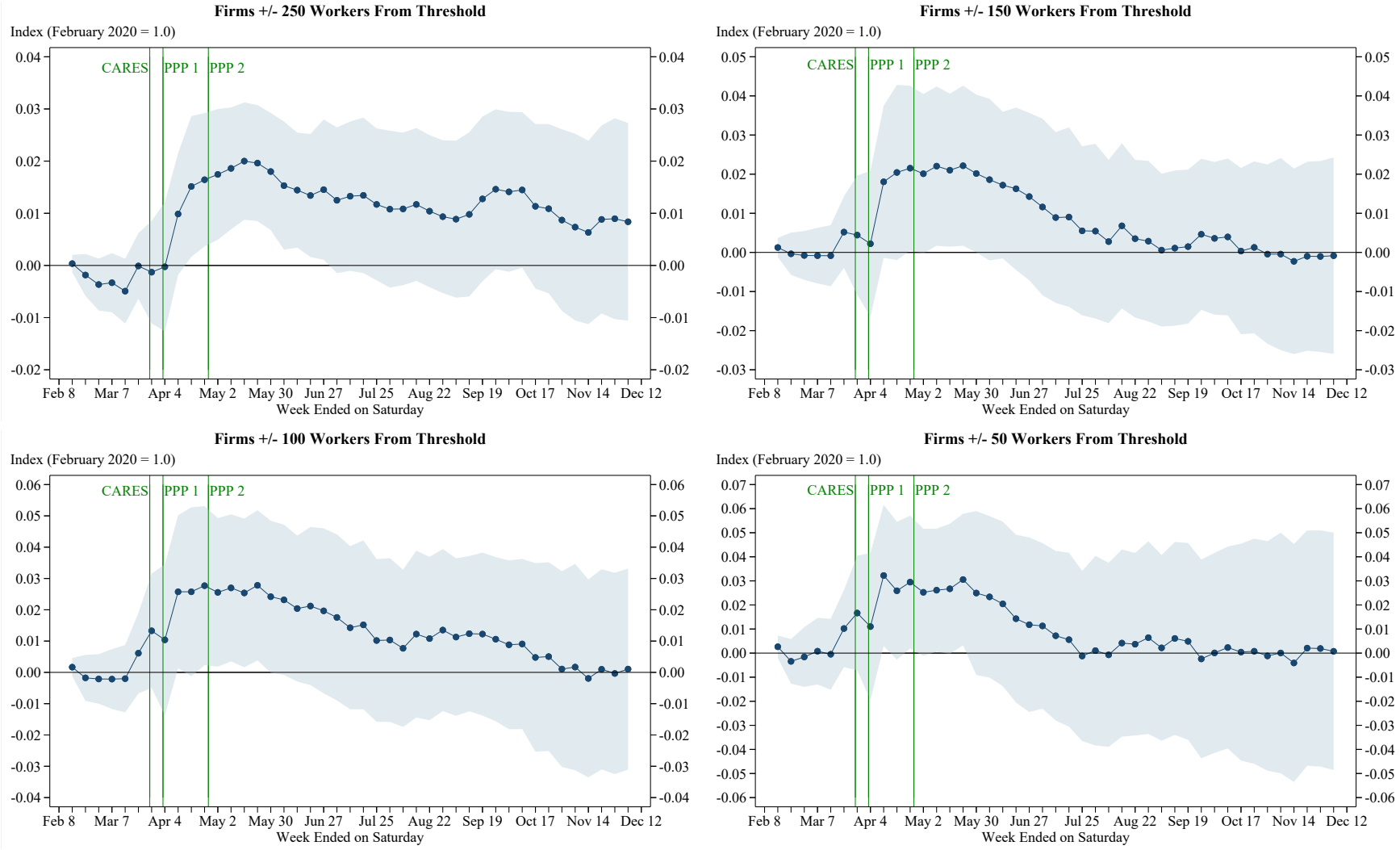
This appendix provides an additional robustness check for our eligibility definitions used for the primary PPP treatment effect estimates (Figure 3). In our main estimates, we determine PPP eligibility using *both* average 2019 employment and February 2020 employment, discarding firms whose PPP eligibility differs across these two measures. Figures G.1 and G.2 present the results of estimating equation (1) with PPP eligibility determined, respectively, by firm average employment in 2019 and by firm employment in February 2020. These estimates are similar to our main findings, with the caveat that those based on February 2020 employment show faster program fadeout. We suspect that assigning PPP eligibility using employment immediately prior to the pandemic provides a less reliable measure of true PPP eligibility. As a result, these ITT estimates may suffer from downward attenuation bias.

Figure G.1: Effect of PPP Eligibility on Employment Based on Firm Size as of 2019



Note: Each firm's size is determined using average employment in 2019. Regressions are weighted by firm size as of February 2020 and include controls for state-by-week and industry-by-week effects. Standard errors are clustered at the 3-digit NAICS industry level. Sample reflects firms that were present in the ADP data for all 12 months of 2019.
Source: Authors' analysis of ADP data.

Figure G.2: Effect of PPP Eligibility on Employment Based on Firm Size as of February 2020



Note: Each firm's size is determined using employment in February 2020. Regressions are weighted by firm size as of February 2020 and include controls for state-by-week and industry-by-week effects. Standard errors are clustered at the 3-digit NAICS industry level. Sample reflects firms that were present in the ADP data for all 12 months of 2019.
Source: Authors' analysis of ADP data.