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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 high-frequency administrative payroll data from ADP—one of the world's largest payroll processing firms—to estimate the causal effect of the PPP on the evolution of 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. The boost to employment waned thereafter and ranged from no effect to a 3 percent boost at the end of 2020. Our estimates imply that employers retained an additional 3.6 million jobs as of mid-May 2020, and 1.4 million jobs at the end of 2020, as a consequence of PPP. The estimated cost per year of employment retained was $169,000 to $258,000, equal to 3.4 to 5.2 times median earnings.

1. Introduction

The onset of the COVID-19 pandemic caused a dramatic plunge in U.S. economic activity, leading many small businesses to shut their doors and leaving many more in precarious financial condition (e.g. Bartik et al., 2020; Bartik et al., 2020). Anticipating further widespread hardship, Congress introduced the Paycheck Protection Program to provide forgivable loans to "small" businesses. Although the PPP had multiple goals, its primary aim was to support recipient firms to maintain employment at pre-pandemic levels. Hence Congress's use of the word "paycheck" in the program name and its requirement that recipient firms spend the majority of PPP funds on wages to qualify for loan forgiveness. The program was economically 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.

This paper provides an assessment of the PPP's efficacy in achieving its primary goal of sustaining small business employment. To provide a high-resolution picture of PPP's effects, we analyze administrative data from ADP—one of the world's largest providers of personnel management services, covering more than 25 million workers in the U.S. These data allow us to observe high-frequency, firm-level employment data at weekly intervals

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throughout the pandemic and to identify a set of firms that were eligible to receive PPP loans and a set that were 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. The threshold is 500 employees for most industries, but not all. We compare these eligible firms to those in a range above the industry-specific 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 the PPP boosted employment at eligible firms, but that these effects faded between the PPP's implementation in the spring of 2020 and the end of the calendar year. 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, and waned gradually thereafter. 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, is precise enough to rule out that the PPP had no effect on employment at that time.

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 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, approximately 27%, in the relevant range *above* the 500-worker threshold as some firms were eligible based on non-size criteria.

By scaling up our intent-to-treat estimates by the difference in take-up rates across the 500-worker threshold and applying them 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 worker retained under two different scenarios. In both scenarios, we extrapolate the trend decline in the estimated PPP treatment effect to the point where it reaches zero in mid-June 2021.

The first scenario relies on our baseline aggregate employment effect estimate. Integrating over treatment time—i.e. from early-April 2020 to mid-June 2021—we estimate that PPP expended approximately $258,000 per full-year job retained, which is almost five times the median full-time, full-year U.S. salary in 2020.

Most PPP loans were issued to smaller firms, however, and it is possible that the PPP boosted employment at these firms—which are more likely to be liquidity constrained—by more than it did at large firms. Since our estimates derive from firms in the vicinity of the eligibility thresholds of 500 workers, they may potentially understate these impacts on smaller firms. We take this caveat seriously under the second scenario by considering a hypothetical where the effect of the PPP for very small firms is double the local treatment effect we estimate here. In this more generous case, the estimated cost-per-job-saved by the PPP is $169,000 (vs. $258,000 above), or 3.4 times the median salary.

These high costs per job retained likely reflect the reality that the PPP program was designed to prioritize rapid aid disbursement over careful targeting Autor et al. (2022). PPP was effectively available to all small businesses, and hence by nature did not target the firms most in need. One consequence was that a large share of PPP dollars appears to have gone to inframarginal firms that would have maintained employment in the absence of the PPP.[2]

Drawing on the strengths of our data, our analysis focuses exclusively on the PPP's effects on employment. We acknowledge however that a complete evaluation would include a broader set of outcomes, including business survival, loan delinquency, and potential general equilibrium effects on the broader macroeconomy. These broader consequences are discussed in Hubbard and Strain (2020) and Autor et al. (2022).

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 those receiving loans later, often exploiting variation in timing due to the varying tendency of local banks to quickly issue PPP loans. This timing approach is complementary to our threshold eligibility approach and permits a direct analysis of the effect of the PPP on smaller firms. Conversely, our threshold approach identifies the effect of the PPP using a well-defined, predetermined, pre-COVID firm characteristic: firm size. This is attractive relative to identification based on the timing of rollout, which arguably requires stronger identifying assumptions to interpret causally. The threshold approach is also 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, after which point, most small businesses had taken up the PPP. From that point forward, the timing approach cannot provide a clean contrast between firms with and without a PPP loan.

Papers using the timing approach have come to a range of PPP employment effect estimates. Autor et al. (2022), Dalton (2021), and Granja et al. (2020) estimate employment effects broadly 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 Bartik et al. (2021), Doniger et al. (2021), Faulkender et al. (2020), Kurmann et al. (2021) though, suggest a substantially larger employment effect than found in this paper.[3]

Our work is also related to the contemporaneous working paper by Chetty et al. (2020), who use the PPP's eligibility size threshold to identify the effect of the program on employment, as we do here. Consistent with the results reported here, they find that employment was boosted by 2% at PPP-eligible firms through August of 2020, although their estimates are not statistically distinguishable 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 stronger assumptions to be interpreted causally; moreover, in some instances these estimates achieve identification through the endogenous choice to take up a PPP loan.[4]

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

[3] These papers generally interpret their relatively larger employment effects as reflecting a more pronounced response among very small firms. That said, Autor et al. (2022) and Dalton (2021) find only modestly larger employment effects for such firms.

[4] See their Table 4, columns (4) and (6), and Figs. 3a and b. 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).

The paper proceeds as follows: Section 2 provides background on the PPP; Section 3 discusses the data and presents graphical analysis; Section 4 presents the intent-to-treat estimates; Section 5 presents the estimates of the aggregate effect of the PPP; and Section 6 concludes.

2. The Paycheck Protection Program

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 of 2021. Unlike loans from the first two tranches, however, most third tranche PPP loans required businesses to demonstrate a significant revenue loss. Because our data lack information on firm revenue, we analyze only the first two tranches of PPP loans from 2020, and all subsequent discussion pertains to the first two tranches except where noted. The complex rules governing the program's eligibility and loan forgiveness were altered over time by Congress. Our discussion here focuses on the final rules applying to the first two tranches. See Autor et al. (2022) and 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 was larger for some industries.[5] 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: payroll expenses had to equal at least 60 percent of the loan amount; total qualifying expenses—which included payroll expenses, utilities, rent, and mortgage payments—had to at least equal the loan amount; and wages had to be maintained at not less than 75 percent of their pre-crisis level.[6] If one or more of these criteria were not met, loans could still be partially forgiven. Ultimately, loan forgiveness was nearly universal, with 96% of 2020 PPP loans forgiven to date (Small Business Administration, 2022).[7]

The attractiveness of the PPP loans led to substantial take-up among eligible firms. 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. See Web Appendix A for more details.

The blue bars of Fig. 1 show the number of employees at firms receiving PPP loans by firm size bracket as measured using PPP loan-level data from the Small Business Administration. The red bars show total employment in the same size bins from the Census Bureau's *Statistics of U.S. Businesses* (SUSB) data for 2017. Employment-weighted take-up—defined as the ratio of the blue bars to the red bars—was high across the size distribution, averaging a bit more than 90%. Appendix B provides additional information.

3. A Preliminary Look at the Data

Our analysis harnesses anonymized and aggregated payroll data, organized as a panel of firm-week observations, from the private-sector firm ADP, which processes payrolls for over 26 million individual workers in the United States per month. 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.[8] 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 discontinued operations with 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 some turnover in ADP's clientele (leading to false closures), we do not expect customer turnover to be correlated with PPP treatment eligibility except through the effect of PPP on firm shutdowns.

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. (2020). Particularly relevant for this paper, Cajner et al. (2020) show that employment indexes derived from the ADP data closely matched the dynamics of the Bureau of Labor Statistics monthly CES data in the early stages of the pandemic. See Appendix C for additional discussion.

Firms are eligible for PPP loans if their employment is either below 500 workers or less than an SBA-specific size threshold (exceeding 500). We exploit this threshold rule to contrast employment outcomes at firms that are above versus below the SBA's employment thresholds. Our analysis accordingly focuses on the subset of relatively larger firms among small businesses, all of which have at least 250 employees. Only 14% of the PPP's 2020 loan volume went to firms with 250 or more employees, meaning that our analysis sample focuses on firms that are substantially larger than the typical PPP-recipient firm. Nevertheless, as shown in Appendix C, our sample of large firms has a sectoral mix broadly similar to that of all PPP-recipient firms. Because virtually all firms in accommodation and food service (NAICS 72) were likely eligible for PPP loans (meaning that there is no natural comparison group), we omit that sector in all analysis.

Prior to the formal analysis, Fig. 2 provides a preliminary look at the evolution of employment among likely-eligible and likely-ineligible firms from early February of 2020, prior to the pandemic's U.S. onset, to late December of the same year.[9] The top panel plots employment indexed to a firm's average level of employment in February 2020 for two size classes: 251-500 (likely eligible, in blue) and 501-750 (likely ineligible, in red). Employment declines symmetrically across these groups through the beginning of the crisis, 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 groups diverge, with employment stabilizing more quickly in firms with 251 to 500 employees. Around two months after the launch of the PPP, employment is approximately 2 percent higher relative to baseline at firms that are likely eligible for PPP loans than

[5] Businesses could also qualify for the PPP if their annual receipts or profits were lower than a given threshold. Lacking firm financial data, we are unable to leverage this alternative revenue cutoff.

[6] There was also a maintenance of employment requirement, but a number of "safe harbor" provisions significantly loosened or eliminated this requirement for many firms.

[7] 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 potentially spend 60 percent of the loan amount on payroll over the 24 week window because the loan size was equal to only 10 weeks of payroll.

[8] This is the same employment concept used by the Bureau of Labor Statistics Current Employment Statistics (CES) data.

[9] Firms in industries with thresholds higher than 500 are excluded from the graphical exercise in Fig. 2. These firms are used in the regression analysis below, where we apply the SBA's industry-specific thresholds to define treatment status.

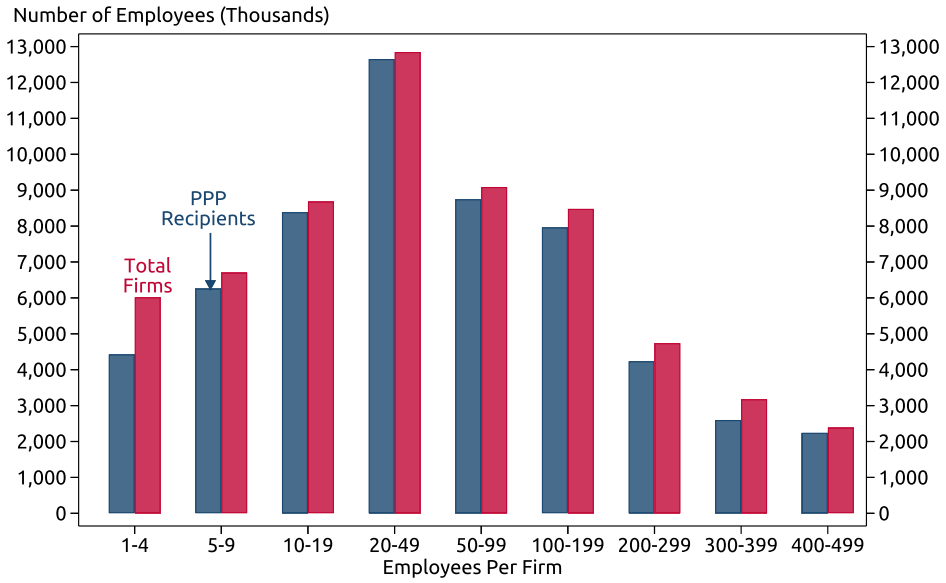

Fig. 1. Distribution of PPP Loans by Firm Size, 1-499. Note: Excludes about 850,000 loans to the self-employed, sole proprietors, independent contractors, single-member LLCs with only one job reported as well as loans to businesses in Puerto Rico, Virgin Islands, and Guam as those types of employers and areas are excluded from the SUSB universe. Source: Authors' analysis of SBA loan-level PPP data and Census Bureau *Statistics of U.S. Businesses*.

at those that are not. From the end of May forward, employment relative to baseline 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 Fig. 2 provides further detail by additionally plotting the evolution of employment at firms further away from the PPP eligibility threshold: those with pre-pandemic employment of either 101-250 workers or 751-1,000 workers. Employment trends in these additional size categories broadly reinforce the pattern seen in the first panel. Employment at firms with 101-250 workers closely tracks those with 251-500 workers, while employment at firms with 751-1,000 workers tracks that of firms with 501-750 workers. Thus, relative to firms with 501–750 employees, employment at firms with 101-250 employees rises by roughly 2 percent from the time of PPP enactment to the end of June 2020, after which point this employment gap gradually closes. These plots suggest that the PPP may have temporarily boosted employment at firms that were eligible to receive loans compared to those that were primarily ineligible. Our subsequent analyses formally explore these relationships.

4. Identification Approach and Primary Estimates

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

One practical challenge in 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 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.[10] In Appendix E, we apply alternative windows for calculating eligibility and obtain results broadly similar to our baseline results.

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

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

where y_{ijst} is total employment for firm i in industry j in state s 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 weeks 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 starting January 5, 2020 through the week starting November 29, 2020 (ending December 5, 2020)—covering the period prior to the crisis, the passage of the CARES Act (March 27th), and through most of the ensuing year.[11] Standard errors are conservatively clustered at the NAICS 3-digit industry level. Finally, we weight the regressions by firm size in February 2020 so that the results can be interpreted as the estimated effect of the PPP on the employment of the average worker employed at the set of firms operating in 2020.

The time-varying β_t vector is the parameter of interest; under our identifying assumptions, discussed below, it traces out the treatment effect of PPP eligibility on employment. The treatment

[10] 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.

[11] Because our weekly ADP data begin in 2020, we commence our analysis of pre-pandemic outcomes at the beginning of that year. We believe that the most informative period for assessing common pre-trends among PPP-eligible and PPP-ineligible firms is the weeks immediately after the pandemic's U.S. onset but prior to PPP's enactment.

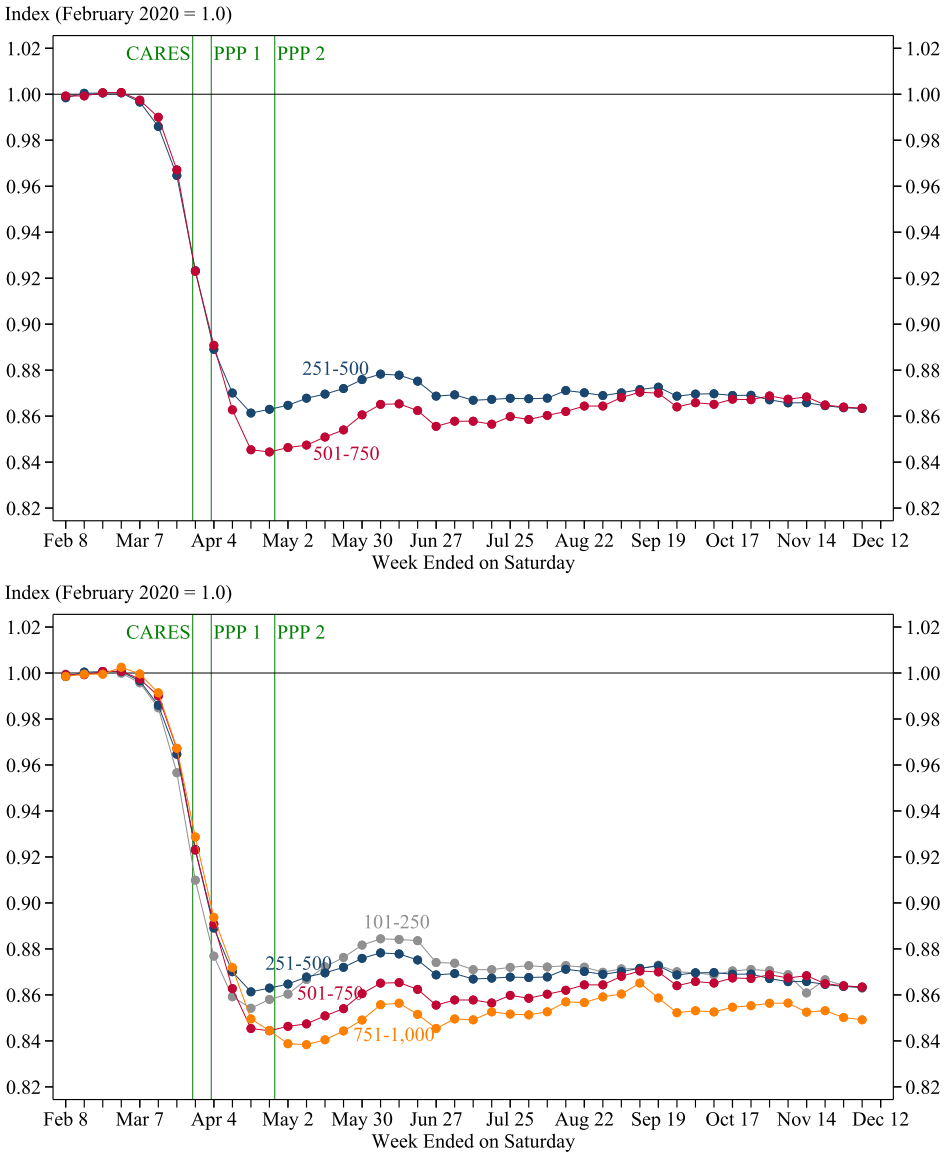

Fig. 2. Employment by Firm Size for Industries With PPP Eligibility at 500 Workers. Note: Each series represents average employment for firms with that particular range of workers in both 2019 and February 2020. Data are weighted by each firm's employment as of February 2020. Sample reflects firms that were present in the ADP data for all 12 months of 2019. Source: Authors' analysis of ADP data.

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 absorb time-varying shocks common to firms within a given industry, while state-week fixed effects absorb time-varying shocks common to all firms in a state. Both sets 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.

The identifying assumption of the empirical 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 violations 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, industry-week and state-week fixed effects control 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.[12]

As an initial check on the comparability of firms above and below the eligibility threshold, Table 1 displays firm summary statistics, including gender composition, industry affiliation, average hourly wages, weekly hours, and weekly earnings. These comparisons show that, apart from size, firms above and below the

[12] The Main Street Lending Facility was potentially available to firms in our control group (Decker et al., 2021). Appendix F discusses why it is unlikely that this significantly affects our estimates of the effect of the PPP program.

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 ($)	1271.8	1277.3	1278.6	1278.8
Hourly Wage Per Worker ($)	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.

eligibility threshold appear quite comparable prior to the crisis. For example, average weekly earnings at firms 0 to 249 workers below the threshold, equal to $1,272, are barely distinguishable from those at firms with 1 to 250 workers above the threshold, equal to $1,277.

Fig. 3 reports our main estimates of Eq. (1). Each panel presents estimates of the β_t vector for a different firm size window. The shaded region in each panel corresponds to the 95 percent confidence interval around the point estimates. These estimates uniformly find a positive treatment effect of PPP eligibility on firm employment. In 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 rises at eligible relative to ineligible firms, increasing by about 2 percent through May, after which the gap attenuates. This contrast is no longer statistically significant from early July forward, 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 subsequent panels of Fig. 3 present estimates for different size windows around the eligibility threshold. These estimates are in all cases qualitatively similar to those in the first panel, though the magnitude of the point estimates at peak PPP efficacy (around May 2020) grows somewhat larger as we shrink the firm size window around the eligibility threshold. When including firms within 150 employees of the eligibility threshold (top-right panel), the estimated peak employment effect is roughly 2.5 percent. This estimate rises to 3.5 percent and 5 percent, respectively, for firms that are within 100 and within 50 employees of the eligibility criteria (bottom-left and bottom-right of the figure). Averaging across all four specifications, the peak effect registers at about 3 percent in mid-May of 2020. After mid-May, the point estimate declines throughout 2020. At the end of the year, the point estimates range from no effect (for the ± 150 window) to about 3 percent (for the ± 50 window), neither of which is statistically significant. Across the four specifications, the point estimates average about 1.2 percent at the end of 2020.

Employment in treatment and control groups was trending in parallel in the pre-PPP period but not thereafter, as shown in Fig. 3, consistent with a causal interpretation of the treatment effect estimates.[13] One anomaly is visible when focusing on firms within 100 employees of the eligibility threshold (bottom-left panel): the treatment effect appears to commence *during* the week of the passage of the CARES Act, which was passed by the Senate on March 25, 2020, and passed by the House and signed into law two days later. In the week prior to the act's passage, there was widespread reporting on an SBA loan program for small businesses with under 500 employees.[14] 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.

Fig. 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. We would accordingly not expect to find a "treatment effect" at the 500 threshold in these sectors. To test this implication, we estimate Eq. (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 as the comparison group. (The minimum actual PPP-eligibility threshold for firms with a non-500 threshold is 750.) Fig. 4 confirms that the placebo treatment effect is near zero in both the pre- and post-PPP period. Appendix G presents the actual PPP treatment effect estimates for the same industries used in the placebo test; the point estimates are broadly similar to our primary results in Fig. 3.

Appendix H discusses results for additional outcomes using the DD research design. We find no evidence that the PPP influenced either the intensive margin of employment (i.e., hours) or the propensity of firms to remain open. Hence, the employment results in Fig. 3 likely reflect the extensive margin adjustment of the number of workers at firms which remained open.

[13] While the estimates in the pre-PPP periods in Fig. 3 are nearly all statistically insignificant, in some cases the estimates appear to be declining prior to the PPP. This raises the possibility that our estimates might understate the employment effect in the post-PPP period. To assess this possibility, we account for these pre-trends using the procedure developed in Freyaldenhoven et al. (forthcoming) and Dobkin et al. (2018). The results are quite similar to our baseline estimates, as discussed in Appendix I.

[14] 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.

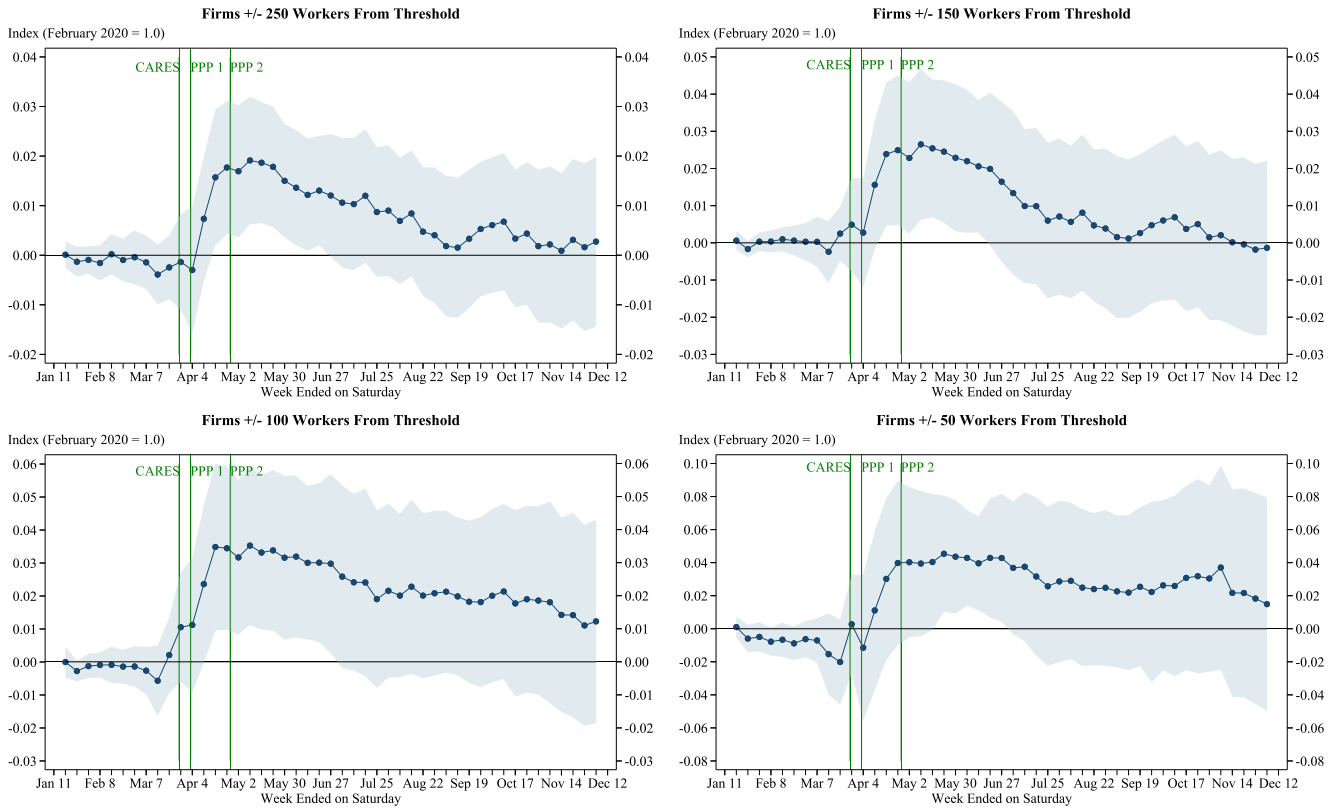

Fig. 3. Effect of PPP Eligibility on Employment. Note: Each firm's size is determined using employment in both 2019 and February 2020. Regressions are weighted by firm size as of February 2020 and include controls for state-by-week and industry-by-week effects. Standard errors are clustered at the 3-digit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

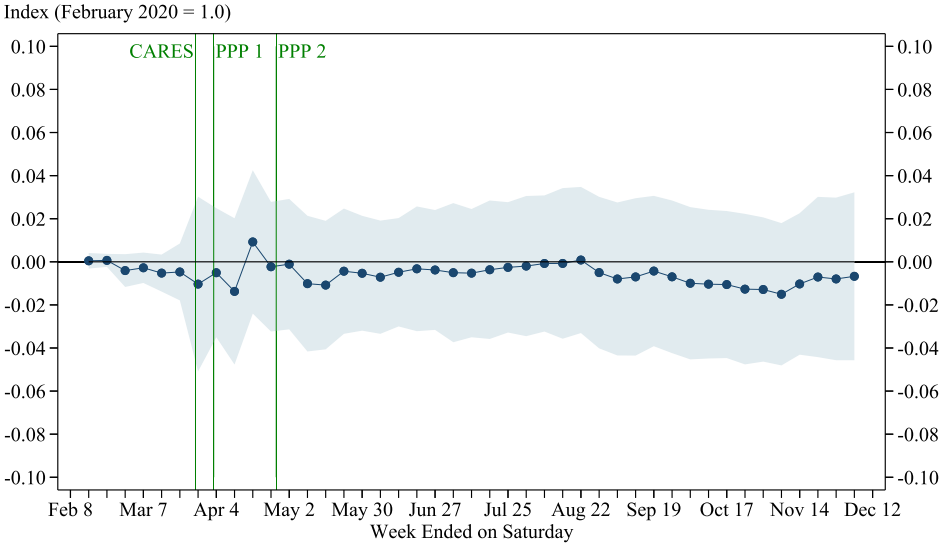

Fig. 4. Placebo Effect of Having 251-500 Workers on Employment for Firms With PPP Eligibility Above 500. Note: Each firm's size is determined using employment in both 2019 and February 2020. Regressions are weighted by firm size as of February 2020 and include controls for state-by-week and industry-by-week 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; firms with 251 to 500 workers form the placebo treatment group and those with 501 to 750 workers form the control group. The sample contains firms that were present in the ADP data for all 12 months of 2019. Source: Authors' analysis of ADP data.

5. Estimating Treatment-on-the-Treated

Our primary results shown in Fig. 3 correspond to intent-to-treat (ITT) estimates, reflecting the effect of loan eligibility rather than take-up on employment. To estimate the effect of *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:[15]

[15] For the sake of simplicity, we use terminal take-up rates; hence the γ's are time-invariant.

$$\delta_t = \frac{\beta_t}{\underline{\gamma} - \overline{\gamma}}. \quad (2)$$

where $\underline{\gamma}$ is employment-weighted PPP take-up among those firms below the SBA size threshold and $\overline{\gamma}$ is employment-weighted take-up among firms above the threshold. The take-up above the threshold reflects, at least in part, that firms with sufficiently small revenues or profits were entitled to PPP loans, despite potentially having more than 500 workers.

Since our primary data source does not record PPP loan receipt, we estimate take-up using SBA loan-level PPP records. Unfortunately, because the size of recipient firms reported in the SBA loan data is truncated at 500 workers, we cannot estimate take-up *below* the industry-specific threshold, $\underline{\gamma}$, for industries with eligibility thresholds above 500 employees. For the same reason, across *all* industries, we cannot directly estimate the take-up rate *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. 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 of the same average size as firms from the 500-999 size bin in the SUSB data. This approach yields an estimate of $\overline{\gamma} \approx 27\%$.

Adjusting for take-up above and below the threshold yields an ATT estimate of $\delta_t = \frac{1}{\underline{\gamma}-\overline{\gamma}} \times \beta_t = \frac{1}{0.81-0.27} \times \beta_t = 1.85 \times \beta_t$. In practice, different firm size bins above and below the eligibility threshold produce slightly different scaling 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 (Appendix Table B.2). See Appendix B for additional information on our ATT estimates, including Figure B.1 which presents estimates of the ATT, a comparison to similar estimates in Chetty et al. (2020), and a discussion of how fraud would influence our ATT estimates.

Applying this scaling factor, we estimate the implied effect of the PPP on total U.S. payroll employment as

$$E_t = \delta_t \times T, \quad (3)$$

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 2020, averaging across the same specifications as shown in Fig. 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 boost of about 1.4 million.

These calculations extrapolate from treatment effects that are estimated from firms in the vicinity of the eligibility thresholds. We noted above that the PPP may have had different effects on smaller firms, which are farther away from the eligibility threshold. If smaller firms were relatively more cash constrained during the crisis, PPP funds may have resulted in a larger share of jobs retained at these firms. Approximately 52% of small business employment is at firms with 1-49 employees, which is plausibly 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%)—consistent with the evidence in Autor et al. (2022)—this increases our estimated peak employment effect from 3.6 million to 5.5 million.

To put these employment numbers in dollar terms, we calculate the cost per year of employment retained 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 Fig. 3, however, suggest that the impact remains positive in that month, although these estimates are statistically insignificant. We conservatively adjust for the effects of PPP on employment after early December 2020 by extrapolating the treatment effect of the PPP (E_t) after our estimation ends using the trend decline observed from the peak effect in mid-May through December 2020. This yields a linearly-declining path of PPP treatment effects that reaches zero in June 2021, shown in Appendix Figure D.1. 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 $258,000 per full-year-equivalent job preserved, or roughly 5.2 times the median worker's salary.[16] Alternatively, using the same extrapolation but assuming that the treatment effect was double for smaller firms, the PPP is estimated to have saved 2.4 million jobs per week at a cost of $169,000, or about 3.4 times the median salary.

6. 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, an effect that 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 retained is equal to 5.2 times the median full-time full-year U.S. salary in 2020. These estimates are identified by PPP-induced changes in employment at firms a good bit larger than the typical PPP-receiving firm. Assuming that small-firm employment was boosted by the PPP by twice as much as large firm employment yields a cost per year of employment preserved of 3.4 times the median salary. Thus PPP outlays very substantially exceeded the salary costs of jobs supported by the program.

A full cost-benefit analysis of the PPP would include several additional margins of potential efficacy not evaluated here. By preventing bankruptcies, the PPP may have preserved valuable intangible firm capital, which could have positive long-run economic

[16] Equal to about $50,000, or 52 times median weekly earnings in the first quarter of 2020 of $949 as measured in the Bureau of Labor Statistics Usual Weekly Earnings series (BLS, 2020).

effects. Additionally, the PPP may also have reduced loan defaults, which would benefit creditors throughout the economy (e.g. suppliers to businesses and commercial landlords) and would 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 preserved their employment, including unemployment compensation, rental assistance, Supplemental Nutrition Assistance Program (SNAP) aid, and other safety-net benefits. A full accounting of these indirect avenues of potential PPP program efficacy, including both their partial and general equilibrium effects, merits significant additional research.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supplementary material

Supplementary data associated with this article can be found, in the online version, at https://doi.org/10.1016/j.jpubeco.2022.104664.

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