ARC Centre of Excellence in Population Ageing Research

Working Paper 2020/18

The Role of Labor Unions in Response to Pandemics: The case of COVID-19

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June 24, 2020

This Version: June 24, 2020

[Latest Version]

Abstract

Labor unions are among the largest institutions in the United States, and their role in regulating employee–employer relations is hard to ignore. Costly efforts to control the spread of COVID-19 (i.e., decreasing economic activity and increasing workplace safety measures), combined with the monopoly and collective voice faces of unions, emphasize the role unions can play in shaping the response of the workforce in coping with COVID-19. We analyze the effect of union size by utilizing state-level data in the United States and by employing a nonlinear probability model and general method of moments estimation. The results suggest new evidence of positive externalities for union employees compared with nonunion employees. We find that a 10% increase in unionization in the United States would lead to around 5% decrease in total cases of COVID-19 100 days after the onset of the virus, controlling for hours of work and differences in union members' characteristics.

1 Introduction

This study investigates the role that labor unions, one of the largest institutions in the United States, play in the spread of COVID-19[1]. Person-to person transmission in the workplace is thought to play a crucial role in the spread of the virus. While a complete shutdown of businesses is neither possible nor optimum for an extended period of time, in the absence of a vaccine marginal alterations in work schedules and appropriate workplace safety measures are vital to the success of efforts to control the spread of the virus. Unions play a role in shaping and regulating employer–employee relations. The direction and significance of the effect of unions on the spread of the virus, however, remain an empirical question.

[1] Around 11% of employees in the United States are represented by unions.

This paper analyzes these effects by utilizing state-level data in the United States and by employing a nonlinear probability model and general method of moments (GMM) estimation.

Freeman and Freeman and Medoff (1984) distinguish between two dimensions of unions: the monopoly face and the collective voice/institutional response face. Through their monopoly power, unions affect the spread of COVID-19 by imposing employees' preferences through the alteration of layoff patterns, compensation benefits, and work conditions. The collective voice face, on the other hand, refers to the institutional impact of unions. Unions increase communication between employees and employers and facilitate the preferences of each to be revealed to the other. Preference revelation itself affects the level of economic activity and safety regulations at the workplace. Also, safety provisions and working schedules display characteristics of a public good. As a result, an adequate level may not be reached in an individual agreement between an employee and their employer [Flanagan (1983)]. Noting that efforts to stop the spread of the virus is public good, the collective voice face of unions not only may impact the spread of COVID-19 through higher nonwage benefits for workers which were supposedly shaped before the pandemic, unions can also play a role in adjusting working conditions during the pandemic by both reflecting and enforcing the optimum level of the costly efforts that satisfy the welfare function of union members[2].

The present study provides new evidence of positive externalities for union employees compared with nonunion employees. It suggests that a 10% increase in unionization in the United States would lead to 54,213 fewer cases of COVID-19 100 days after the onset of the virus[3]. The study also finds that when the intensive margin of labor supply is controlled, this effect is even more substantial. It suggests that while unions provide a safer workplace

[2]The International Union, United Automobile, Aerospace and Agricultural Implement Workers of America (UAW) claims to monitor and assess the situation while engaging with workers to help address some of the workplace issues that the COVID-19 crisis has presented. The statement is available at: uaw.org/coronavirus

[3]The total number of cases at day 100 is 1,042,457, which suggests approximately a 5% decrease in total cases.

in terms of COVID-19, union employees, compared to nonunion employees, increase their labor supply. In other words, union employees utilize their collective bargaining power to achieve a safer workplace and simultaneously keep labor supply unchanged.

Uncovering the effect of unionization on the spread of COVID-19 contributes to the strand of economic literature that studies the externalities of labor unions from the insider–outsider point of view; this suggests that unions can help nonunion employees and the unemployed by slowing the spread of the virus. Also, considering unions as organizations with specific functionalities and channels through which they work helps to unfold the role each channel has, regardless of the entity in which those channels are rooted. Unions can reduce the costs of transmitting information between employees and employers (preference revelation), increasing the majority's power by reflecting the collective voice, and hence, increasing the possibility of imposing measures that are better suited to the majority of employees. These channels can play the same role in other democratic organizations that share the same structures as unions. This means that if there are inconsistencies between employees' weights over consumption and health and those of the government or firms, a comparison between unionized and nonunionized employees reveals those inconsistencies since we expect union members to have a more powerful voice. This study provides evidence on better optimization by smaller democratic organizations rather than state or federal governments, emphasizing the role of better information flows in smaller organizations with a powerful voice derived from collective bargaining power. As a result, understanding the role organizations such as unions play in efforts to prevent the spread of contagious viruses helps to implement policies that will respond better to contagious diseases in the future.

The remainder of the paper is organized as follows. After describing the mechanisms through which unions may affect the spread of the virus in section 2, in section 3 we discuss the estimation method and the model employed. Section 4 discusses the identification strategy, and section 5 describes the data. Section 6 provides the results, and section 7 concludes the paper.

2 Mechanisms

Employees and firms (as economic agents) play an important role in determining the transmission rate of COVID-19 by making multiple work-related decisions. These decisions can be broadly categorized into decisions about the level of safety measures and decisions about the level of economic activity. We expect that by reducing economic activity and increasing safety measures, the spread of the virus will slow down. However, both measures are costly to agents. Also, at least in the short term, there is a trade-off between the level of economic activity and occupational safety in the event of a pandemic. Hence, the level of restrictive measures should be optimized, considering weights of consumption (employment) and health in the utility and profit function of employees and firms, respectively. In the absence of unions, federal and state governments are the only agents affecting the decision-making processes of employees and firms. They do this by setting social distancing restrictions and advising businesses on how to provide a safe workplace. Unions as a form of collective bargaining in employer–employee relations (as opposed to individual bargaining) can affect the rules and effectiveness of social distancing restrictions.

Depending on the monopoly power they possess, unions affect the bargaining power of their members (enforcement mechanism) and reduce information transmission costs (preference revelation) between employers and employees [Boxall and Purcell (2011)]. They provide their members with better contracts thereby guaranteeing more job security and better wages. Unions increase the probability of their members receiving employer-provided health insurance [Buchmueller et al. (2002)]. Ninety-one percent of unionized workers can take paid sick leave compared with 73% of nonunionized workers [Pizzella and Beach (2019)]. Unionized workers are slightly more likely to have paid leave, and their paid leave benefits are significantly higher in dollar value [Mishel et al. (2012)]. Also, they are more likely to receive employer-provided pensions and health insurance with a far larger impact on the magnitude of benefit [Pierce (1999), Budd and Na (2000)]. Longitudinal studies also show that a decline in union density explains approximately one-fourth of the decline in aggregate health insurance and pension coverage [Bloom and Freeman (1992); Strombom et al. (2002)). Since efforts to control the spread of the virus are costly for both employers and employees, these factors may help union members to better protect themselves from contagious diseases by shifting protection costs to firms (by utilizing medical services, decreasing work hours, and increasing work safety measures while remaining employed). Freeman (1981) suggests that unions reflect median voter preferences. While nonunionized firms provide compensation in the form of bonuses to the marginal worker, the median worker has a higher demand for nonwage benefits.

With regard to the preference revelation mechanism, unions can affect protection levels. Since information about an individual's health is private, a lack of information prevents the employer from reaching an optimal decision in terms of the level of job safety necessary for operation. In such cases, an employer may ask its employees to attend an unsafe workplace, or conversely, implement unnecessary regulations at work. Unions, in this case, increase transparency by revealing employees' health levels to the firm, and also by informing employees about their rights, their contracts, and the perspective of the whole industry. In the absence of a union this information would be costly for employees to acquire. Thus, higher unionization levels can be helpful in controlling the contagious disease if unions inform employees about their rights, and this could lead to better workspace safety. In contrast, if the union's evaluation of the future of the industry is pessimistic, it can help union members and employers to cooperate by attending a less safe workplace and keeping production costs low, which leads to maintaining union members' jobs and the firm's profit currents. As a result, unions can positively or negatively affect the spread of the virus from the perspective of transparency and trust among employees and employers.

Considering that in the case of a contagious disease such as COVID-19, the benefits of slowing down the spread of the virus are not limited to employees and union members, it is plausible to consider health and better protective measures as a public good. Without an enforcement mechanism, public goods like preventive measures would be undersupplied. Higher levels of such public goods could yield higher social and individual welfare (which we assume is guiding the government's interventions). Since the safety of the work environment is a public good, it is unlikely that it will be provided sufficiently by firms without external pressure. As a result, some governmental intervention in the competitive solution is justifiable. Weil (1999) shows these type of interventions are more of a union supplement than a substitute, and unions play a substantial role in the enforcement of the Occupational, Safety, and Health Act (OSHA) in the manufacturing sector [Weil (1991)].

Governments and unions optimize safety measure levels and economic activities by choosing health and employment levels. However, they differ in at least in two aspects: the information set they possess and the objective function they target. Ideally, the government optimizes the social welfare function and incorporates broad information about individual preferences. On the other hand, unions are expected to optimize the same aspects for their members only, using a more narrowly defined information set, one limited to its members. These differences in objective functions, and the quality and volume of information, lead to the questions of how and to what extent unions are contributing to contain the spread of the virus. Owing to the rapidly growing and unprecedented nature of the COVID-19 pandemic, the government's information about the weight individuals assign to their health is limited, and thus the government's objective function may not reflect the social welfare function. Unions have more detailed information with regard to their members' preferences as a result of having closer contact with them. This means they are more effective in both collecting information about preferences and imposing restrictions. However, unions are not necessarily targeting the same level of restrictions as governments. The characteristics of union members can affect the union's objective function. Collective bargaining may increase the probability of infection if the collective decision of the union is in favor of working more (e.g., in cases where individuals believe the disease is less dangerous for them than it is for the average individual in the community).

A union's externalities can be seen as direct and indirect externalities. As a direct effect, unions alter the probability of union members being exposed to COVID-19 which itself affects the spread of the virus. However, the effect of unions on working conditions is not limited to union members or unionized workplaces. An indirect externality of unions can be described as unions setting standards for work conditions that could be adopted by the labor market in general [Western and Rosenfeld (2011)]. As a related example, higher union density rates are associated with lower levels of economic inequality [Alderson and Nielsen (2002); Alderson et al. (2005); Atkinson (2003); Western and Rosenfeld (2011); Neal (2013)]. The collective bargaining power of unions is not limited to the firm itself. Bargaining takes place at upper levels such as industry, state, and national levels. Hence, unions contribute to pushing through legislation on social programs that impact society in general, such as national social security, unemployment compensation, and minimum wage law [Asher et al. (2001); Galenson (1986)].

Lastly, and as briefly mentioned in the previous section, unions play a crucial role in both guiding the policies concerning COVID-19 and enforcing the advised guidelines[4]. Policies

[4] The American Federation of Labor-Congress of Industrial Organizations (AFL-CIO) has been actively negotiating OSHA, Congress, federal agencies, and state and local governments during the COVID-19 pandemic. AFL-CIO's statement is available at: aflcio.org

toward controlling the spread of the COVID-19 virus might be more successful in the presence of unions.

3 Model

Our modeling approach is based on estimating an individual's probability of infection. This is done by incorporating a logistic model for individual infection and aggregating the results to reach the total number of infections at state level.

The assumption behind aggregating the individual probabilities is independence between the individual probabilities. To address the dependencies between individual observations (probability of infection for one person changes as other people become infected), we integrate elements of the compartment modeling approach into our model. Compartment modeling, which was formulated by Kermack and McKendrick (1927), is well studied in the epidemiology literature and concerns the prediction of the spread of contagious diseases. We borrow the elements of a simple compartment model in which there are two compartments between which individuals are allowed to move. Individuals are either susceptible or infected at every point in time. Using the state as the relevant geographic unit, the probability of being infected (conditional on not being infected at the time) is a function of the total number of infected in the state in the previous period (day). Next, we multiply the individual probability of being infected in each state by the total number of susceptible individuals in the state to reach the total number of new cases. In other words, by controlling for the spread of the virus, provided with the elements of compartment modeling, we can use a logistic probability where we control for the dependence between individual probabilities. To improve predictive power, we further control for state-level characteristics. Lastly, we augment the predictive model with another set of variables that address the identification of the marginal effect of interest, including the differences in state-level characteristics between union members and variables to isolate the treatment effect (union size in each state). Our probability model can be written as:

$$y_{jd} = S_{jd} * Pr(\zeta_{jd}) + \epsilon_j \tag{1}$$

where y_{jd} is the number of new cases in state j and day d, and S_{jd} is the number of susceptible individuals in state j and day d. The ideal probabilistic model should use individual-level observations. In a situation where the outcome is only available at the state level, using individual-level characteristics imposes a high level of computational expenses. To avoid these computational complexities, we use state-level averages[5]. In other words, $\zeta_j d$ is a linear combination of the state j and day d average socioeconomic characteristics X_{jd} , the set of variables representing trends G_{jd}, and lastly, social distancing restrictions which are set by the government R_{jd}. The linear index is defined as:

$$\zeta_{jd} = \bar{X}_{jd}.\beta_X + G_{jd}.\beta_G + R_{jd}.\beta_R \tag{2}$$

For each state-day, we use CPS monthly data to calculate the average socio-economic characteristics of the state-day[6]:

$$\bar{X}_{jd} = \frac{1}{n_{jd}} \sum_{i \in j} x_{id} \; \forall j \tag{3}$$

where n_{jd} is the total sample size (weighted by proper sampling weights) in state j and day d, and x_{id} is a vector of socio-economic characteristics[7] in the individual-level. We further augment X_{jd} by a set of variables which are available in state-level[8] and set at their pre-COVID levels. Trends (G_{jd}) includes time trends[9] , the total number of cases in the

[5] This assumes that the state-day average reflects the individual-day characteristics and ignores the bias due to Jensen's inequality that is in play in the presence of a nonlinear probability function.

[6] The socio-economic characteristics are on a monthly basis.

[7] Including age, education, family income, white, living in metro area, married, family size, and male.

[8] This set of variables consists of the urban structure including Commercial accessibility and Local self-dependence; Commute to work including driving, public transportation, travel time, and working from home; Political preference; Health; And coordinates.

[9] Day since first case in the U.S., and day since first case in state.

previous day $MA(1)$, and a neighboring effect measure that reflects the spread of the virus in surrounding states:

$$\lambda_{jd} = \sum_{k \neq j} \frac{y_{j(d-1)}}{(D_{kj})^2} \tag{4}$$

where y_{jd} is the number of new cases in region j on day d, and D_{kj} is the distance between regions j and k. The neighboring effect λ controls for the contamination between state-level observations. As a result, an increase in the number of cases in a neighboring region affects region j, where the same increase in a region distant from region j has a smaller impact.

While there are multiple alternatives for incorporating social distancing restrictions into the model, we find the following functional form reliable:

$$R_{jd} = \log\left(d - d_{j,R}\right), \quad \forall\ d > d_{j,R} + \bar{d}_R \tag{5}$$

where d is the current day and $d_{j,R}$ is the day on which the restriction level reached level 3 (out of five possible restrictions) in state j. We assume that restrictions will be reflected in the data only after two weeks ($\bar{d}_R = 14$) and for all the dates before $d_{j,R} + \bar{d}_R$, R_{jd} is equal to zero.

To estimate the set of coefficients $(\vec{\beta}_X, \vec{\beta}_G, \vec{\beta}_R)$ we use a GMM estimator with a logistic function as the link function. An unweighted GMM estimator minimizes the following statement with respect to the coefficients:

$$\left(\widehat{\vec{\beta}_X}, \widehat{\vec{\beta}_G},\ \widehat{\vec{\beta}_R}\right) = \underset{\tilde{\beta}_\mathrm{X}, \tilde{\beta}_\mathrm{G}, \tilde{\beta}_\mathrm{R}}{\operatorname{argmin}} \left(\mathrm{y_{jd}} - \mathrm{S_{jd}} \times \frac{1}{1 + \exp\left(-\zeta_\mathrm{jd}\left(\tilde{\beta}_\mathrm{X}, \tilde{\beta}_\mathrm{G}, \tilde{\beta}_\mathrm{R} | \bar{\mathrm{X}}_\mathrm{jd}, \mathrm{G_{jd}}, \mathrm{R_{jd}}\right)\right)} \right)^2 \tag{6}$$

Since we use the logistic link function, y_{jd} can be interpreted as the number of new cases decomposed into the probability of becoming infected by the virus for a person, multiplied by the number of people who are prone to the virus (susceptible) in state j and on day d.

4 Identification

We assume that the structure of the unions and the unionization level remain unchanged in the period of study. This assumption is based on rigidity in union membership and contracts that increase employers' layoff costs. That is, in response to the spread of the virus, union size does not change. This assumption is supported by monthly CPS data, which suggest that union size remains statistically the same as in the pre COVID-19 period, while total employment size drops post COVID-19. Moreover, since union members usually have multi-year contracts, union wages are less flexible than is otherwise determined by the market [Kaufman (2004)]. Rones (1981) claims that these multi-year agreements are restrictive to the point that they encourage firms to use early retirement as a tool to manage workforce flow in times of recession.

To gain a better understanding of the channels through which unions contribute to the spread of the virus, we also control for hours of work for both union members and all employed individuals. This isolates the effect of union size. As a result, the marginal effect calculated for changes in union size better reflects the intrinsic role of unions [10].

Union members can use their collective voice to alter their work hours in response to the spread of the virus. If there is endogeneity between intensive margin and spread of the virus, calculated marginal effects for union size may be biased. Our analysis shows that changes in union members' hours of work before and after COVID-19 are not statistically significant. In addition, the magnitude of the change in hours of work is smaller for union workers versus total employed workers (see Figure C.1 for more details). Also, considering the size of the union compared to the labor force, we do not expect this endogeneity channel to play a significant role. That is, as long as the marginal changes are in the local neighborhood of the sample averages, the calculated marginal effects can be considered as a close approximation of the correct effects.

The other controls we include in the model contain: the characteristics of union members

[10] For example, the safety measures utilized in union versus nonunion establishments.

and those of the whole sample to separate any effects their characteristics might have on the spread of the virus [11]; employment rates; occupation categories; and hours of work in the previous week for both union members and employed individuals.

The inclusion of occupations prevents bias due to the possible concentration of union jobs in occupations with lower (higher) than average risk of contracting COVID-19. Also, by controlling for employment rates and hours of work for all employed individuals, estimated marginal effects of union size are defined as changes in the spread of the virus if a nonunion worker becomes a union member, keeping the number of employed people constant. Hence, the marginal effects are not convoluted by entries and exits in the job market and only reflect movement between union and nonunion employees.

5 Data

We utilize daily generated data on the number of cases and deaths due to COVID-19, collected by the *New York Times*[12]. These include the number of new and total cases in each state-day.

Socioeconomic and union coverage data are mostly based on CPS data. We use monthly CPS data from January to April 2020 to extract the variables representing individuals' characteristics, family structure, and income. The right-hand side column in Table 1 reports the related summary of statistics. Also, the CPS is used to determine the work-related status of individuals. This includes union membership and coverage of wage and salary employees reported by CPS. We follow Hirsch and Macpherson (2003) in calculating union status and use BLS weights, which are also used by the U.S. Bureau of Labor Statistics[13].

The left-hand side column in table 1 shows the summary of statistics for the variables

[11] A total of seven categories for occupation including two digits occupation based on the Census Occupational Classification (six categories) and a specific code for healthcare practitioners and technical occupations, and healthcare support occupations.

[12] Data from The New York Times, based on reports from state and local health agencies. The repository of data: https://github.com/nytimes/covid-19-data

[13] Our results are robust to the choice of weight we use. Using household weights only slightly affects the results and neither changes the statistical nor economic significance of any of the main results.

which are not directly derived from CPS. These variables include health, political preference, urban structure, commute to work, and coordinates. To incorporate urban structure, we use commercial accessibility and local self-dependence measures developed by Rahimzadeh (2020), representing the density of urban structure and commercial accessibility in each state, respectively (see Appendix C for more details).

Table 1: Summary of statistics.

	Total Sample		Not in Labor Force	Employed	Unioned
Commercial Accesibility	0.07	Age	55.58	44.10	44.77
	(.02)		(2.49)	(1.33)	(3.05)
Local self dependence	6.24	Education	1.89	2.25	2.36
	(1.18)		(.13)	(.19)	(.34)
Political preference (Democrat)	0.45	Family Income (1000$)	67.15	97.27	100.22
	(.12)		(9.96)	(13.63)	(18.9)
Drive	77.16	% White	79.23	79.94	79.21
	(8.43)		(14.48)	(12.99)	(18.6)
Public	3.86	% living in Metro area	21.38	23.60	21.79
	(6.56)		(16.94)	(17.55)	(18.95)
Home	4.30	% Married	46.40	54.26	59.63
	(1.05)		(4.5)	(4.23)	(13.89)
Travel Time	22.93	Family Size	2.62	2.88	2.83
	(3.47)		(.23)	(.2)	(.42)
Health (More is poorer health)	2.44	% Male	41.72	52.71	53.94
	(.14)		(2.28)	(1.82)	(13.51)
Longitude	-93.34				
	(19.1)				
Latitude	39.46				
	(6.01)				
Weekend	0.43				
	(.49)				

6 Results

We analyze the effect of a 10% increase in union size on the total number of confirmed COVID-19. Marginal effects are based on the simulation of the daily spread of the virus under two scenarios: current and counterfactual level of unionization. The standard errors are bootstrapped using 100 iterations (See Appendix A). Table 2 provides, in 10-day intervals starting from day 50 of the onset of the COVID-19 virus in the United States, a detailed picture of the goodness of fit and the marginal effects for each of the nine census divisions. Middle Atlantic states have the highest rates of infection, while West North Central states are affected the least. The GMM estimator we use in this study weights the states by the number of confirmed cases in each state. Hence, the estimates are more affected by those states with a higher number of confirmed cases. This is reflected in a very well fitted simulation in more affected states and an overestimation of the number of cases for less-affected regions. Figure 1 depicts the continuous trajectory of total cases, separated for the four census regions (see Figure A1 for daily number of new cases). Figures 2 departs from the time-space and depicts new cases against total number of cases. More specifically, Figure 2 separates the relationship for each census region from the onset of the virus in the United States for observed, current, and counterfactual simulations. It suggests that, increasing the union size shifts the inverse U relationship down and helps to control the spread of COVID-19.

To a lesser degree, the results can also be utilized to highlight the differences in the objective functions of government and individuals. In the case of an unpredicted pandemic such as COVID-19, the weights governments assign to consumption and health of people in the social welfare function is not necessarily correct (i.e., up to date). While federal and state governments set restrictions to control the spread of the virus, individuals are in a better position to assess their health, financial condition, and preferences regarding health and consumption. We can test this hypothesis by comparing union members (whose voice is echoed) with employed individuals who are not covered by a union. Unions—due to their collective power—have more visibility and hence are able to employ measures that are closer to the collective optimum of their coalition. Hours of work have declined for both total employed individuals and union workers. However, the decline is large in value and statistically significant for the total number of employed, whereas it is comparatively small and statistically insignificant for union workers. That is, when empowered by unions, individuals decide to work more than employed individuals who have the government as the sole intervening third party (See Figure C.1 for more details).

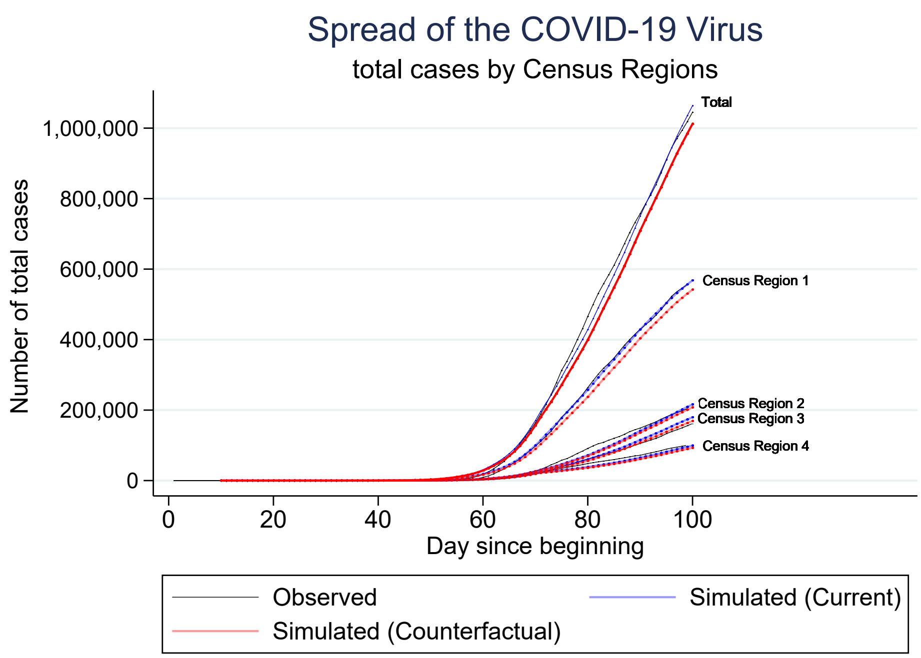

Figure 1: Total number of COVID-19 cases (observed and simulated).
This graph shows the observed and simulated spread of COVID-19 in the United States under the current level of unionization and counterfactual level of unionization, where we increase the unionization level by 10% while keeping the employment level constant. Also presented is the spread for different census regions following categorization by the U.S. Census Bureau.

It is worth noting that a closer to optimum outcome does not necessarily mean less spread of the virus, and the direction of the effect remains an empirical question. Unions with members who are healthier than others in society or who have lower preferences regarding health may choose to reduce their effort level and hence help spread the virus. On the other hand, union members may benefit from a safer workplace by more successfully transmitting

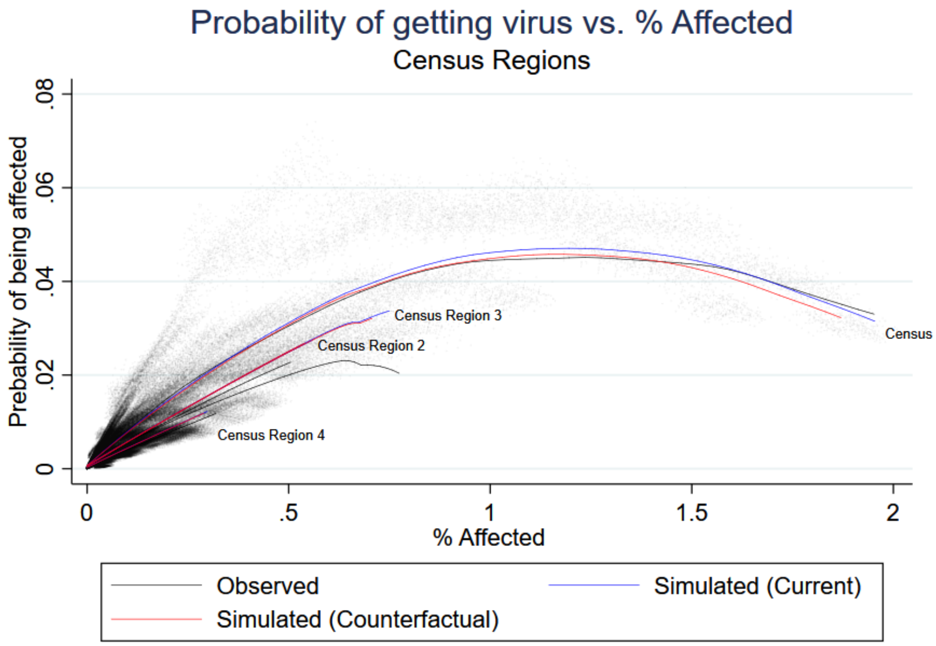

Figure 2: Probability of infection conditional on percent of people infected for each census region (observed and simulated).
This graph depicts the simulated relationship between the number of new cases and the total number of COVID-19 cases, separated by the different census regions as provided by the U.S. Census Bureau. Census Region 1 is where the virus has spread the most. Census Region 4 is the least affected region.

their preferences to their employers.

7 Conclusion

Efforts to stop the spread of COVID-19 can be seen as a public good. In other words, it is costly for agents (individuals or firms) with a particular level of effort, while other individuals can reap the benefits. As a result, the benefits of the efforts cannot be constrained to the agent who bears the costs. Thus, agents with the highest preferences for health, those with poorer health, or those who are wealthier possibly bear the costs, and other agents take a 'free ride'. Like other examples of public good, efforts to prevent the spread of the virus are under-supplied, and to achieve the optimum level of a public good, the government or a third-party entity should intervene and provide motivation and regulations to satisfy a certain level of public good in society. This paper investigates the role of labor unions in the spread of a contagious virus such as COVID-19.

Unions may affect the work environment through the channels discussed in the literature, namely, monopoly power and information transparency. Depending on the structure of the union and the characteristics of union members, they may use their collective bargaining power to increase safety in the work environment, leading to a decrease in the spread of the virus. Furthermore, they may more efficiently transmit employees' private health information to the firm, and as a result, establish safety measures that are closer to the optimum level. Also, unionized workers have a clearer picture of the firm's profit perspective since they can negotiate terms with their employers. Hence, a more efficient outcome in terms of employment and workplace safety is expected. However, a more efficient outcome does not necessarily mean that the virus will spread less.

Our analysis shows that ceteris paribus, a local increase in unionization level leads to better control of the spread of COVID-19. This is despite the fact that union members have not decreased their hours of work in response to the spread of the virus. In other words, unionization has positive externalities that are reflected in a slower spread of the virus.

This study does not address the general equilibrium aspects of the change in union size. That is, labor supply (for both intensive and extensive margins) and a firm's profit are altered neither by direct changes in unionization level nor by indirect changes due to the effect of unionization on the spread of the virus. To analyze the net and longer-term effects of a change in unionization further studies with general equilibrium aspects that endogenize labor market responses are required.

Table 2: Simulated current and counterfactual levels of unionization by census division.

Census Division		Day 50	Day 60	Day 70	Day 80	Day 90	Day 100
New England (1)	Observed	105	792	9,576	32,459	63,816	99,251
	Simulated	156	1,438	8,350	30,624	63,050	99,018
	Δ	-11	-108	-636	-2,025	-3,910	-5,510
		(3)	(24)	(143)	(486)	(979)	(1415)
Middle Atlantic (2)	Observed	200	8,278	88,254	231,442	365,034	467,449
	Simulated	1,992	17,379	91,944	228,060	366,622	469,843
	Δ	-220	-1,901	-9,711	-18,972	-22,345	-21,991
		(55)	(459)	(2297)	(4519)	(5511)	(5511)
East North Central (3)	Observed	33	1,595	16,566	52,546	88,863	131,947
	Simulated	225	3,238	18,479	45,598	86,315	135,896
	Δ	-18	-279	-1,598	-3,276	-5,638	-8,335
		(4)	(61)	(351)	(737)	(1304)	(1951)
West North Central (4)	Observed	40	376	2,815	8,477	16,528	30,008
	Simulated	90	992	5,392	14,888	29,603	44,763
	Δ	-6	-66	-359	-955	-1,854	-2,731
		(1)	(16)	(86)	(224)	(440)	(650)
South Atlantic (5)	Observed	82	1,699	14,197	47,629	82,382	119,086
	Simulated	277	2,695	14,804	40,309	80,641	123,645
	Δ	-11	-114	-644	-1,724	-3,539	-5,721
		(3)	(26)	(151)	(407)	(853)	(1385)
East South Central (6)	Observed	14	486	3,996	11,079	18,982	28,344
	Simulated	52	749	4,175	10,828	20,517	30,129
	Δ	-1	-23	-134	-352	-662	-970
		()	(6)	(36)	(87)	(163)	(238)
West South Central (7)	Observed	39	1,063	8,049	32,484	47,749	62,179
	Simulated	126	1,339	7,564	21,065	40,363	62,666
	Δ	-4	-39	-223	-704	-1,380	-2,106
		(1)	(11)	(62)	(182)	(350)	(523)
Mountain (8)	Observed	31	826	6,615	16,591	25,643	37,507
	Simulated	132	1,352	7,524	14,579	23,938	34,559
	Δ	-6	-61	-336	-627	-1,008	-1,427
		(2)	(16)	(89)	(154)	(241)	(338)
Pacific (9)	Observed	474	2,852	13,529	31,793	46,150	66,686
	Simulated	248	2,133	12,766	24,401	41,956	65,935
	Δ	-20	-174	-1,043	-2,002	-3,456	-5,422
		(5)	(45)	(270)	(495)	(842)	(1304)
Observed Total Cases		1,018	17,967	163,597	464,500	755,147	1,042,457
Simulated Total Cases		3,297	31,313	170,997	430,351	753,005	1,066,453
Marginal Effect		-296	-2,766	-14,684	-30,636	-43,792	-54,213

This table shows the detailed results for Model 5. We separate the results into nine census divisions. For each census division, observed and simulated total number of COVID-19 cases are reported for 10-day intervals starting from day 50 (where simulation begins). Marginal change refers to the simulated marginal effect of a 10% change in unionization level, keeping the employment level constant. The standard errors of marginal change are shown in parentheses. Assuming t-statistic distribution for the marginal effects, all of the simulated marginal effects are statistically different from zero, at least at the 90% confidence level. Also worth noting, simulation closely replicates the observed data, showing the prediction power of the model for in-sample prediction, which itself reflects that the model takes the endogenous channels into account even after controlling for monthly changes in characteristics.

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Appendix A Calculation of Marginal Effects

To calculate the marginal effect of unionization on the total number of COVID-19 cases at a particular point in time, we aggregate the total number of new cases under the current level of unionization and counterfactual levels. We have:

$$\Delta_d = \sum_{t=1}^{d} \left(S_{jt,0} \times \frac{1}{1 + exp\left(-\zeta_{jt}\left(\widehat{\vec{\beta}_X}, \widehat{\vec{\beta}_G},\ \widehat{\vec{\beta}_R} | X, G, R\right)\right)} \right) - \sum_{t=1}^{d} \left(S_{jt,\Delta} \times \frac{1}{1 + exp\left(-\zeta_{jt}\left(\widehat{\vec{\beta}_X}, \widehat{\vec{\beta}_G},\ \widehat{\vec{\beta}_R} | X + \Delta X, G, R\right)\right)} \right)$$

Note that in the first term, $S_{jt,0}$ is a function of previous new cases under the current level of unionization, and is different from its counterpart in the second term, which is affected by a change in unionization level and affects and reflects the whole trajectory of the number of new cases. As a result, we cannot calculate the marginal effect solely by translating the GMM estimates through the logistic function. Instead, the marginal effect should be simulated from the day the first case is observed in each state.

We employ a simulation-based approach, where social distancing restrictions and the day on which the first case occurs in each state are exogenous. Next, we simulate the daily spread of the virus under two scenarios: current and counterfactual level of unionization. The standard errors are bootstrapped using 100 iterations, where in each iteration we draw the parameters from the multinomial joint distribution of parameters $(\widehat{\vec{\beta}_X}, \widehat{\vec{\beta}_G},\ \widehat{\vec{\beta}_R})$.

After simulating the results for both scenarios (current and counterfactual level of unionization), we show the marginal effects by day. Since the current policy is also simulated, we can compare the goodness of fit—resulting from the GMM estimator—by comparing observed data of the spread of the virus and simulated current policy.

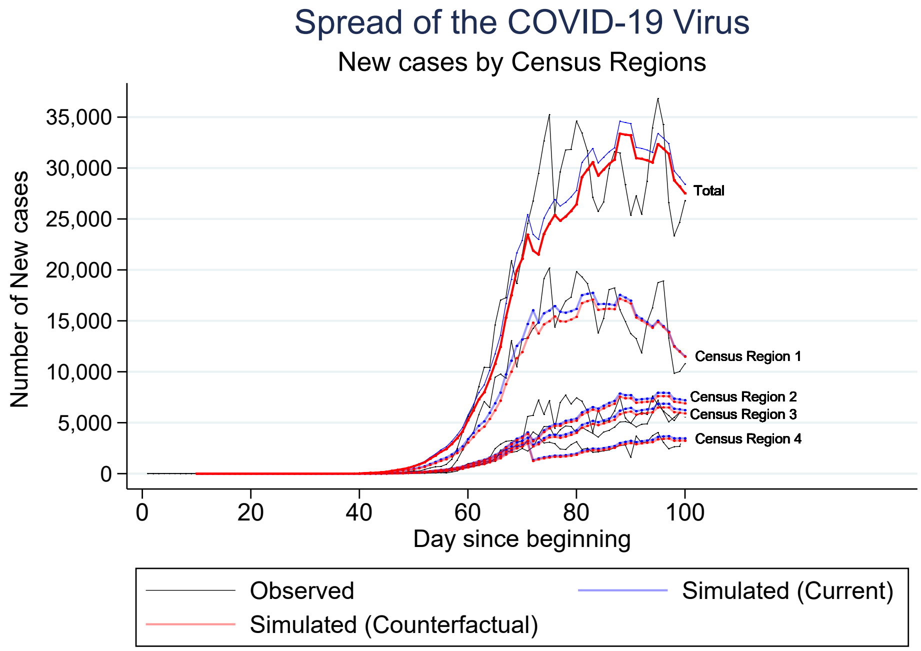

Figure A.1: Number of new COVID-19 cases (observed and simulated)

TObserved and simulated number of new cases of COVID-19 are shown in the graph for the whole United States and different census regions, as suggested by the U.S. Census Bureau. For each category, we provide simulation under the current level of unionization and simulation under the counterfactual level of unionization, where we increase the unionization level by 10%, keeping the employment level constant (Model 5 in Table B.1).

Appendix B Specifications

We analyze the effect of a 10% increase in union size on the total number of confirmed COVID-19 cases using five different specifications. Table B.1 shows the marginal effects and characteristics of each specification. Model 1 includes trends and state-level characteristics. Detailed specifications of these variables are shown in column (1) of Table B.2. Since Model 1 does not control for union size, it cannot be used for marginal effect calculations. However, it provides a comparison point by showing the goodness of fit of the model when it does not include any of the policy variables.

In Model 2, we add occupation-specific union size in each state. As we are able to differentiate between union members' characteristics and those of the other residents of each state, we also control for the characteristics of those who are represented by a union (Table B.2). As shown in Table B.1, the simulated marginal effect under Model 2, at day 100 since the outbreak of the virus in the United States, is –23,612 with a relatively small standard error of 9,494.

Model 3 controls for the occupation-specific size of employment in each state. By incorporating this new dimension, it is less likely for the marginal effect of union size to capture the concentration of union workers in jobs that are more (or less) dangerous since the onset of COVID-19. The simulated marginal effect of union size using Model 3 compared to that calculated by Model 2 shows that in terms of COVID-19, the distribution of union workers among different occupations is similar to the distribution of employed individuals. In other words, union jobs are not concentrated in occupations with a higher (or lower) chance of infection. The marginal effects of Model 3 are shown in Table B.1.

Model 4 is augmented by controls for hours of work in the last week among union workers. This allows for a more in-depth analysis of the channels, as it separates the effects of changes in the work schedules from those of the unions. Lastly, Model 5 adds another control for work hours in the last week among all employed individuals. As shown in Table B.1, the marginal effect of a 10% increase in union size is constantly negative and statistically significant among all four models (Models 2 through 5). Comparing it with the marginal effect of a comparable increase in the number of employed individuals (Models 4 and 5 in Table B.1) shows that the effect of an increase in union size is negative, while more employment positively affects the number of confirmed cases. It is worth noting that an increase in union size results from a change in union status (from nonunion member to union member) of individuals who are already employed. In contrast, an increase in employment is derived from a change in employment status (from unemployed to nonunion employed).

Comparing it with the marginal effect of a comparable increase in the number of employed individuals (Models 4 and 5 in Table B.1) shows that the effect of an increase in union size is negative, while more employment positively affects the number of confirmed cases. It is worth noting that an increase in union size results from a change in union status (from nonunion member to union member) of individuals who are already employed. In contrast, an increase in employment is derived from a change in employment status (from unemployed to nonunion employed).

Appendix C Data

As explained in the Section 5, we utilize daily generated data on the number of cases and deaths due to COVID-19, collected by the New York Times. Figure C.2 shows the scatter plot of the number of observed new cases against the total number of cases for each state at day 100 since the outbreak of the virus. The continuous line is an estimated local polynomial and shows an inverse U-shaped relationship.

To include state-level variations in health we use self-reported health, which is reflected in BRFFS 2018 data. This is then combined with latitude and longitude associated with the centroid of counties represented by individuals and average weighted over states (leading the coordinates to being closer to the populous counties in each state).

Commercial accessibility and local self-dependence measures are based on Rahimzadeh (2020). Representing the density of urban structure and commercial accessibility in each state, these two measures are built by calculating the related index for each 60 x 60 meter cell covering the whole state and averaging at the state level . Associated with urban structure, is a set of covariates which we include to control for utilization of public transport, working from home, and driving to work, using state-level data from the Bureau of Transportation Statistics. Lastly, we use the state-level restrictions repository from The Institute for Health Metrics and Evaluation. Table C.1 reports the detailed level of restrictions in each state.

Table B.1: Simulated marginal effects

		1	2	3	4	5
Union size by Occupation			Yes	Yes	Yes	Yes
Employment by Occupation				Yes	Yes	Yes
Hours of union					Yes	Yes
hours of work						Yes
Simulated Marginal Effect	Union Size		-23,612	-53,287	-52,778	-54,213
			(9,494)	(12,811)	(15,188)	(13,150)
Simulated Marginal Effect	Employment			104,147	104,285	93,627
				(15,842)	(16,849)	(15,920)
MSE		600,639	507,727	499,966	502,486	501,780
GMM criterion		10	0	13	15	14
# of Observations		(3,488)	(3,488)	(3,488)	(3,488)	(3,488)

This table shows the simulated marginal effects for different models. Models are augmented gradually from Model 1 (the simplest model) to Model 5 (the model with the most controls). Model 1 uses variables only incorporated for prediction purposes, as shown in the first column of Table B1. Model 2 incorporates union size by different occupations (six main categories) and also differentiates between the characteristics of union members and those of the whole sample. The marginal effect calculated in Model 2 is prone to bias due to the possibility of union concentration in occupations with lower/higher risk of being affected by COVID-19. In Model 3, we control for employment in each occupation, and hence, it is less likely to suffer from the bias caused by the non-orthogonality between COVID-19 and occupation. Model 4 adds hours of work of union workers in the previous week, and hence, the marginal effect that this model reports is net of the effect due to the changes in working schedules for union workers. Model 5 also controls for hours of work for total employed people in the previous week. Model 5 is the most reliable since it separates hours of work and occupational concentration effects for both employed and union workers. The simulated marginal effect is the difference between the different simulated paths, under current and counterfactual policies, from day 50 to day 100 of the spread of the virus. Before day 50, there are not enough observations to simulate the results reliably. Standard errors for each marginal effect are shown in parentheses.

Table B.2: Estimated GMM coefficients of a logistic model.

	1	2	3	4	5
Total cases in previous day	233.33 (21.22)	53.07 (21.25)	5.72 (21.86)	1.47 (21.79)	-2.39 (21.79)
Neighboring effect	-6.20 (3.26)	6.68 (3.37)	7.27 (3.76)	9.35 (3.73)	10.08 (3.72)
Commercial Accesibility	-48.75 (20.42)	-75.90 (29.18)	-107.72 (27.46)	-110.45 (30.85)	-134.27 (30.07)
Local self dependence	2.39 (.5)	1.84 (.44)	5.62 (.97)	5.55 (.96)	5.70 (.9)
Driving To work	0.04 (.03)	0.10 (.03)	0.15 (.04)	0.10 (.04)	0.11 (.04)
Using Public Transportation	0.05 (.04)	0.21 (.04)	0.20 (.06)	0.14 (.06)	0.16 (.06)
Working from Home	-0.18 (.06)	-0.21 (.07)	0.41 (.09)	0.48 (.11)	0.39 (.1)
Travel time to Work	0.20 (.03)	0.00 (.02)	0.34 (.06)	0.35 (.06)	0.31 (.05)
Log(day since regulation began)	-0.35 (.02)	-0.31 (.02)	-0.28 (.03)	-0.29 (.03)	-0.29 (.03)
Political preference (Democrat)	3.23 (1.9)	15.15 (2.07)	7.81 (3.66)	7.42 (3.68)	11.51 (3.33)
Health (More is poorer health)	36.26 (13.82)	36.42 (17.68)	41.03 (.)	26.77 (.)	42.77 (.)
Longitude	-0.01 (.)	-0.02 (.01)	-0.02 (.01)	-0.01 (.01)	-0.02 (.01)
Latitude	0.07 (.02)	-0.02 (.01)	0.12 (.02)	0.14 (.02)	0.12 (.02)
Day since first case in the U.S.	0.36 (.01)	0.40 (.01)	0.50 (.02)	0.49 (.02)	0.50 (.02)
Day since first case in state	-0.02 (.)	-0.03 (.01)	-0.06 (.01)	-0.06 (.01)	-0.06 (.01)
(Total cases in previous day)^2	-15,748.2 (1010.75)	-5,797.5 (765.07)	-4,347.2 (787.71)	-4,262.3 (786.78)	-4,210.7 (789.08)
(Neighboring effect)^2	47.21 (25.28)	-14.02 (20.01)	3.95 (20.96)	-6.87 (20.88)	-11.75 (20.92)
(Day since first case in the U.S.)^2	-1.75 E-03 (6.8 E-05)	-1.94 E-03 (6.9 E-05)	-2.32 E-03 (8.9 E-05)	-2.31 E-03 (8.9 E-05)	-2.32 E-03 (8.9 E-05)
(Day since first case in state)^2	1.05 E-04 (2.6 E-05)	1.43 E-04 (3.0 E-05)	2.15 E-04 (3.2 E-05)	2.06 E-04 (3.2 E-05)	1.92 E-04 (3.3 E-05)
Political preference (Democrat)^2	-4.36 (2.)	-14.40 (2.51)	-6.18 (3.38)	-5.91 (3.52)	-8.16 (3.27)
(Health)^2	-7.91 (2.7)	-7.46 (3.48)	-8.73 (.19)	-5.93 (.18)	-8.80 (.19)
Commercial Accesibility^2	390.79 (118.87)	471.14 (186.09)	889.81 (193.85)	888.70 (212.89)	1,041.94 (209.04)
Local self dependence^2	-0.18 (.04)	-0.14 (.03)	-0.40 (.07)	-0.40 (.07)	-0.41 (.07)

Table B.3: Estimated GMM coefficients of a logistic model (Continued).

		1	2	3	4	5
Age	Total	-0.02	-0.04	-0.06	-0.03	-0.07
		(.026)	(.044)	(.048)	(.048)	(.05)
Age	Union		0.06	0.14	0.14	0.13
			(.011)	(.013)	(.013)	(.014)
Education	Total	-12.67	-0.89	-57.89	-71.97	-67.73
		(5.6)	(6.721)	(7.07)	(8.89)	(9.146)
Education	Union		5.03	4.15	4.69	5.18
			(.711)	(.916)	(.918)	(.904)
Family Income	Total	-0.10	-0.15	-0.13	-0.09	-0.08
		(.028)	(.037)	(.031)	(.031)	(.032)
Family Income	Union		-0.03	-0.07	-0.09	-0.10
			(.012)	(.015)	(.015)	(.015)
% White	Total	0.23	0.11	0.96	1.07	1.01
		(.071)	(.028)	(.106)	(.121)	(.11)
% White	Union		0.00	-0.02	0.00	-0.01
			(.009)	(.01)	(.01)	(.01)
% living in Metro area	Total	-0.01	0.01	0.00	-0.01	-0.01
		(.003)	(.005)	(.006)	(.006)	(.006)
% living in Metro area	Union		-0.02	-0.01	0.00	0.00
			(.003)	(.003)	(.004)	(.004)
% Married	Total	-0.08	-0.05	-0.04	-0.03	0.00
		(.014)	(.013)	(.018)	(.017)	(.018)
% Married	Union		-0.01	-0.02	-0.03	-0.02
			(.003)	(.003)	(.003)	(.003)
Family Size	Total	-0.47	-0.22	0.46	1.12	1.00
		(.302)	(.399)	(.431)	(.441)	(.434)
Family Size	Union		0.00	0.65	0.70	0.62
			(.095)	(.106)	(.116)	(.113)
Weekend		0.07	0.07	0.07	0.07	0.07
		(.029)	(.025)	(.025)	(.025)	(.025)
% Male	Total	-2.90	-3.62	-4.34	-3.19	-4.36
		(.705)	(.883)	(.266)	(.299)	(.334)
% Male	Union		-0.02	-0.01	-0.01	0.00
			(.009)	(.012)	(.012)	(.011)
(Family Income)^2	Total	4.7 E-04	1.0 E-03	4.7 E-04	1.2 E-04	1.0 E-04
		(1.5 E-04)	(2.2 E-04)	(1.8 E-04)	(1.9 E-04)	(1.9 E-04)
(Family Income)^2	Union		1.2 E-04	3.1 E-04	4.1 E-04	4.6 E-04
			(6.3 E-05)	(7.5 E-05)	(7.6 E-05)	(7.3 E-05)
% White^2	Total	-1.5 E-03	-6.6 E-04	-6.6 E-03	-7.4 E-03	-7.0 E-03
		(5.0 E-04)	(1.8 E-04)	(7.4 E-04)	(8.5 E-04)	(7.7 E-04)
% White^2	Union		-6.8 E-05	1.7 E-04	9.9 E-05	1.6 E-04
			(7.1 E-05)	(8.1 E-05)	(7.5 E-05)	(7.7 E-05)
% Male^2	Total	3.0 E-02	3.9 E-02	4.7 E-02	3.5 E-02	4.7 E-02
		(7.6 E-03)	(8.9 E-03)	(3.6 E-03)	(4.0 E-03)	(4.1 E-03)
% Male^2	Union		1.2 E-04	1.4 E-04	2.1 E-04	1.0 E-04
			(7.8 E-05)	(1.0 E-04)	(1.0 E-04)	(9.6 E-05)
Education^2	Total	2.99	-0.10	13.38	16.86	15.94
		(1.346)	(1.648)	(1.652)	(2.078)	(2.13)
Education^2	Union		-1.09	-0.78	-0.81	-0.95
			(.157)	(.201)	(.199)	(.195)

Table C.1: Applied restrictions in states and DC.

State	Mass gathering restrictions	Initial business closure	Educational facilities closed	Non-essential services closed	Stay at home order	3/5 Restrictions appliead
Delaware	16-Mar-20	16-Mar-20	16-Mar-20	24-Mar-20	24-Mar-20	16-Mar-20
Maryland	16-Mar-20	16-Mar-20	16-Mar-20	23-Mar-20	30-Mar-20	16-Mar-20
Michigan	13-Mar-20	16-Mar-20	16-Mar-20	23-Mar-20	24-Mar-20	16-Mar-20
New Mexico	12-Mar-20	16-Mar-20	13-Mar-20	24-Mar-20	N/I	16-Mar-20
Washington	11-Mar-20	16-Mar-20	13-Mar-20	25-Mar-20	23-Mar-20	16-Mar-20
Connecticut	12-Mar-20	16-Mar-20	17-Mar-20	23-Mar-20	N/I	17-Mar-20
DC	13-Mar-20	17-Mar-20	16-Mar-20	25-Mar-20	30-Mar-20	17-Mar-20
Louisiana	13-Mar-20	17-Mar-20	16-Mar-20	22-Mar-20	23-Mar-20	17-Mar-20
Ohio	12-Mar-20	17-Mar-20	16-Mar-20	23-Mar-20	23-Mar-20	17-Mar-20
New Jersey	16-Mar-20	16-Mar-20	18-Mar-20	21-Mar-20	21-Mar-20	18-Mar-20
New York	12-Mar-20	16-Mar-20	18-Mar-20	22-Mar-20	22-Mar-20	18-Mar-20
Wisconsin	17-Mar-20	17-Mar-20	18-Mar-20	25-Mar-20	25-Mar-20	18-Mar-20
California	11-Mar-20	19-Mar-20	19-Mar-20	19-Mar-20	19-Mar-20	19-Mar-20
Hawaii	16-Mar-20	17-Mar-20	19-Mar-20	25-Mar-20	25-Mar-20	19-Mar-20
Indiana	12-Mar-20	16-Mar-20	19-Mar-20	24-Mar-20	25-Mar-20	19-Mar-20
Utah	17-Mar-20	19-Mar-20	16-Mar-20	N/I	N/I	19-Mar-20
Alabama	20-Mar-20	20-Mar-20	19-Mar-20	28-Mar-20	4-Apr-20	20-Mar-20
Kentucky	19-Mar-20	18-Mar-20	20-Mar-20	26-Mar-20	N/I	20-Mar-20
Wyoming	20-Mar-20	19-Mar-20	19-Mar-20	N/I	N/I	20-Mar-20
Illinois	13-Mar-20	21-Mar-20	17-Mar-20	21-Mar-20	21-Mar-20	21-Mar-20
Nevada	19-Mar-20	21-Mar-20	16-Mar-20	21-Mar-20	31-Mar-20	21-Mar-20
Texas	21-Mar-20	21-Mar-20	19-Mar-20	N/I	2-Apr-20	21-Mar-20
Colorado	19-Mar-20	17-Mar-20	23-Mar-20	26-Mar-20	26-Mar-20	23-Mar-20
Massachusetts	13-Mar-20	23-Mar-20	17-Mar-20	24-Mar-20	N/I	23-Mar-20
Missouri	23-Mar-20	17-Mar-20	23-Mar-20	N/I	6-Apr-20	23-Mar-20
Oregon	12-Mar-20	24-Mar-20	16-Mar-20	N/I	23-Mar-20	23-Mar-20
Pennsylvania	1-Apr-20	23-Mar-20	17-Mar-20	23-Mar-20	1-Apr-20	23-Mar-20
Rhode Island	17-Mar-20	23-Mar-20	16-Mar-20	N/I	28-Mar-20	23-Mar-20
Tennessee	23-Mar-20	23-Mar-20	20-Mar-20	1-Apr-20	2-Apr-20	23-Mar-20
Vermont	13-Mar-20	23-Mar-20	18-Mar-20	25-Mar-20	24-Mar-20	23-Mar-20
Alaska	24-Mar-20	17-Mar-20	16-Mar-20	28-Mar-20	28-Mar-20	24-Mar-20
Georgia	24-Mar-20	24-Mar-20	18-Mar-20	N/I	3-Apr-20	24-Mar-20
Montana	24-Mar-20	20-Mar-20	15-Mar-20	26-Mar-20	26-Mar-20	24-Mar-20
Virginia	15-Mar-20	24-Mar-20	16-Mar-20	N/I	30-Mar-20	24-Mar-20
West Virginia	24-Mar-20	18-Mar-20	14-Mar-20	24-Mar-20	25-Mar-20	24-Mar-20
Idaho	25-Mar-20	25-Mar-20	23-Mar-20	25-Mar-20	25-Mar-20	25-Mar-20
Maine	18-Mar-20	25-Mar-20	16-Mar-20	25-Mar-20	2-Apr-20	25-Mar-20
North Carolina	14-Mar-20	25-Mar-20	14-Mar-20	30-Mar-20	30-Mar-20	25-Mar-20
Oklahoma	24-Mar-20	25-Mar-20	17-Mar-20	1-Apr-20	N/I	25-Mar-20
Arkansas	27-Mar-20	19-Mar-20	17-Mar-20	N/I	N/I	27-Mar-20
Minnesota	27-Mar-20	17-Mar-20	18-Mar-20	N/I	27-Mar-20	27-Mar-20
New Hampshire	16-Mar-20	28-Mar-20	16-Mar-20	28-Mar-20	27-Mar-20	27-Mar-20
Arizona	30-Mar-20	20-Mar-20	16-Mar-20	N/I	30-Mar-20	30-Mar-20
Kansas	17-Mar-20	N/I	17-Mar-20	N/I	30-Mar-20	30-Mar-20
South Carolina	18-Mar-20	1-Apr-20	16-Mar-20	N/I	7-Apr-20	1-Apr-20
Nebraska	16-Mar-20	19-Mar-20	2-Apr-20	N/I	N/I	2-Apr-20
Florida	3-Apr-20	17-Mar-20	17-Mar-20	N/I	3-Apr-20	3-Apr-20
Mississippi	24-Mar-20	3-Apr-20	19-Mar-20	3-Apr-20	3-Apr-20	3-Apr-20
Iowa	17-Mar-20	17-Mar-20	4-Apr-20	N/I	N/I	4-Apr-20
North Dakota	N/I	20-Mar-20	16-Mar-20	N/I	N/I	
South Dakota	6-Apr-20	N/I	16-Mar-20	N/I	N/I	

N/I is *Not in Effect*

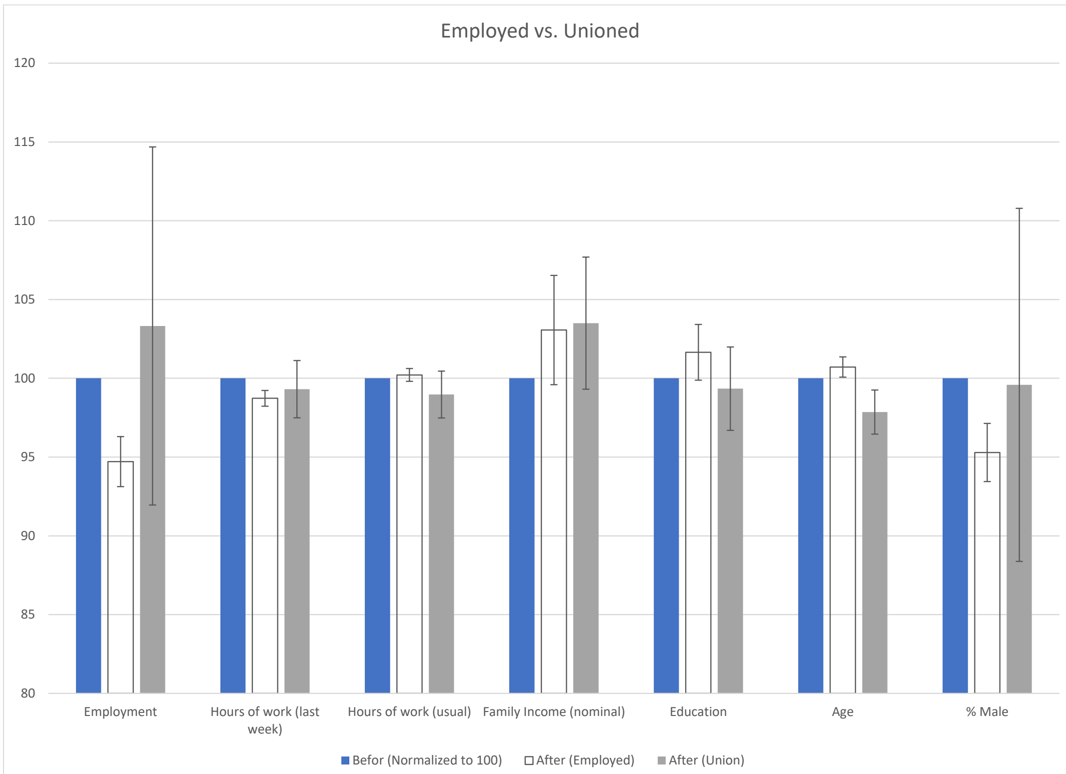

Figure C.1: Changes in characteristics (employed and union members)

Changes in size and characteristics of union and total employed workers, before and after the onset of COVID-19, are depicted for the United States. Before refers to the characteristics extracted from CPS data in January 2020. After refers to the average of characteristics for three consecutive months: February, March, and April. Particularly important are the first two categories from the right: employment (extensive margin) and hours of work last week (intensive margin). Consistent with the identification assumption in the paper, the spread of COVID-19 affects total employment but does not affect employment for unionized workers (change in employment for union workers is positive but statistically insignificant). The same is true for hours of work last week. It is worth noting that both extensive and intensive margins are more positive for unionized workers than total employed workers.

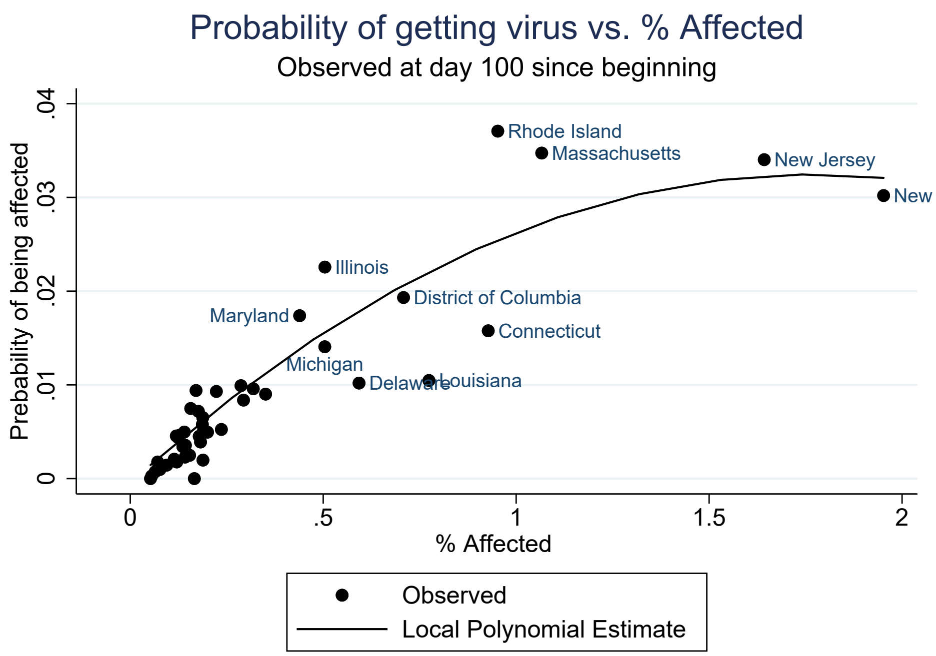

Figure C.2: Probability of infection conditional on percent of people infected in state (observed)

This graph shows the relationship between the observed number of new cases and the total number of cases for different states. As the number of new cases grows, the spread of the virus slows.