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The Union Threat

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This article develops a search theory of labour unions in which the *possibility* of unionization distorts the behaviour of non-union firms. In the model, unions arise endogenously through a majority election within firms. As union wages are set through a collective bargaining process, unionization compresses wages and lowers profits. To prevent unionization, non-union firms over-hire high-skill workers—who vote against the union—and under-hire low-skill workers—who vote in its favour. As a consequence of this distortion in hiring, firms that are threatened by unionization hire fewer workers, produce less and pay a more concentrated distribution of wages. In the calibrated economy, the threat of unionization has a significant negative impact on aggregate output, but it also reduces wage inequality.

Key words: Labor unions, Trade unions, Macroeconomic impact of unions, Inequality, Workplace conflict, Strike.

JEL Codes: J50, J41, E24

1. INTRODUCTION

As unions are now covering only about 7% of private sector jobs in the U.S., many observers have argued that their impact on the aggregate economy must be small. In opposition to this view, this article investigates how unions can nonetheless have a sizable impact on the macroeconomy through their influence on *non-union* firms. Indeed, if unionization lowers profits, like many studies find, vulnerable non-union firms might distort their behaviour to prevent their own unionization. Through that channel, unions may influence employment, wages, and output in many nonunion firms and, therefore, have a larger impact on macroeconomic aggregates than the unionization rate alone would suggest.

To analyse this mechanism, this article proposes a novel general equilibrium theory of endogenous union formation in which each firm hires multiple workers who differ in their productivity. In the model, unionization is simply a way for the workers to force the firm into a different wage setting mechanism. If a simple majority of the workers vote in favour of unionization, a union is created and wages are bargained collectively between the firm and its employees. If, instead, the vote fails to gather enough support, the firm remains union-free and wages are bargained individually between each worker and the firm.

By changing how the surplus from production is split, unionization generates a conflict between the firm and its employees. Indeed, since collective bargaining allows the workers to extract a higher share of the surplus, creating a union increases the average wage and lowers profits. But unionization also creates a second conflict, this time between the workers themselves. As collective bargaining compresses the distribution of wages, high-productivity workers tend to

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vote against the creation of the union, while low-productivity workers tend to vote in its favour. To avoid unionization, the firm can therefore hire more high-skill workers and fewer low-skill workers to increase the employees' opposition to the union and push the outcome of the vote in its favour.

This change in hiring in response to the threat of unionization is not motivated by production efficiency and leads to a higher marginal cost of production. As a consequence, threatened firms hire fewer workers, produce less and, because of decreasing returns to labour, pay higher wages. The threat also affects the variance of wages through the change in hiring. Since the firm over-hires high-productivity workers, their marginal product goes down as do their wages. The opposite happens to low-productivity workers, and non-union firms therefore pay a narrower range of wages in response to the threat of unionization.

In the model, the labour market is subject to search frictions so that it takes time for workers to be matched with vacancies. The unemployment rate is also affected by the union threat. In general equilibrium, as threatened firms hire fewer workers, the unemployment rate goes up and it takes more time for workers to find jobs. Since unemployment becomes less attractive, firms are able to extract a higher share of the production surplus which also pushes wages down.

The model provides a microfounded bargaining theory of unionization that is able to replicate important empirical facts associated with unions: (i) union wages have a smaller variance and are on average higher than non-union wages (Card *et al.*, 2004), (ii) the preference for unionization and the difference between union and non-union wages decrease with skill (Farber and Saks, 1980), and (iii) unionized firms are on average less profitable than their non-union counterpart (Hirsch, 2004).

To quantify the impact of the union threat, I estimate the model using data from the private sector of the U.S. in 2005, and I use the parametrized economy to conduct three experiments in general equilibrium. In the first experiment, the formation of new unions is prohibited. As a result, non-union firms no longer need to take action to prevent unionization and this first experiment therefore captures the impact of the threat of unionization alone, as the union status of the firms remain unchanged. In the new general equilibrium, output and the variance of log wages go up by about 1.2%, while the unemployment rate decreases by about 1.5 percentage points. If, in addition to removing the threat, all union firms are forced to become union free, the variance of log wages goes up by an additional 6.5%, but output and unemployment are not further affected. This second experiment therefore suggests that the threat of unionization on its own, more than the fact that some firms are actually unionized, might be a key channel through which unions affect output and unemployment in the U.S. economy. Finally, in the third experiment all firms are forced to be unionized. Comparing this new equilibrium to the calibrated economy, the variance of log wages goes down substantially while output and employment increase more than in the experiment in which unions were banned. The article also shows that often-used reduced-form estimators tend to underestimate the full impact of labour unions on wage inequality. For instance, the classical Freeman (1980) estimator finds that, in the calibrated economy, unions reduce the variance of log wages by 3.63% while their true impact is of 7.73%. More sophisticated estimators that take into account the heterogeneity between workers do worse by suggesting that unions lower the variance of log wages by only 0.72%. These large differences between reduced-form and model-based estimators can be partly explained by the threat of unionization, as it induces non-union firms to pay a more equal distribution of wages. Standard estimators do not capture this channel.

The theory also provides an explicit mechanism to explain why some regression discontinuity studies, such as DiNardo and Lee (2004), find little impact of unionization on firms. These studies compare firms before and after unionization. But according to the theory firms before unionization are actively distorting their behaviour in response to the threat. As a result, regression discontinuity estimators only capture part of the full impact that unions have on firm behaviour.[1]

Finally, I provide supporting evidence for the mechanisms of the model by using the passage of right-to-work laws by some U.S. states as a source of variation in union strength. These laws prevent labour unions and employers from signing contracts that requires that workers pay union membership fees as a condition of employment. As a result, under these laws unions have access to fewer resources, which leads to a weaker threat of unionization. Through a series of regressions, I find that the passage of a right-to-work law is associated with lower earnings for non-union workers, suggesting that non-union firms no longer feel the need to pay high wages to prevent unionization.

1.1. *Literature review*

Rosen (1969) was perhaps the first to mention that the threat of unionization could affect nonunion firms. Dickens (1986) considers the impact of the union threat on a firm's employment and wage level in a static environment in which workers can form coalitions to force the firms into specific work contracts. In contrast, the current article proposes a dynamic, general equilibrium framework with heterogenous workers to evaluate the impact of the union threat on wage inequality, output and unemployment. Corneo and Lucifora (1997) also consider a model in which firms preemptively increase wages if they believe a union will force costly negotiations.

This article is also part of a literature that includes labour unions in search models. Pissarides (1986) finds that introducing a monopoly union with control over the wage in a search framework might lead to efficiency. Alvarez and Veracierto (2000) study the impact of many labour market policies in a search model and find that unions who control hiring have adverse effects on unemployment and welfare. Ebell and Haefke (2006) and Delacroix (2006) investigate the interaction between union formation and product market regulations. Boeri and Burda (2009) look into the impact of an endogenous bargaining regime on economic activity. Açikgöz and Kaymak (2014) estimate the impact of a rising skill premium on the decline of union membership in the U.S. Krusell and Rudanko (2016) have studied the dynamic problem of a monopoly union that sets wages with or without commitment. None of these papers investigate the impact of the threat of unionization on decision makers and the macroeconomy.

Several empirical papers find reduced-form evidence that the threat of unionization affects the behaviour of firms. Part of that literature uses the passage of right-to-work laws across U.S. states as a source of variation in union strength. Farber (2005) finds that nonunion wages fell by 4.2% after the passage of a right-to-work law in Idaho in 1981. More recent work has shown that the threat remains active today. For instance, Manzo and Bruno (2017) investigate the impact of right-to-work laws that were enacted between 2012 and 2015 in Indiana, Michigan, and Wisconsin. Controlling for a variety of factors, they find a decline of 2.3% in nonunion wages after the legislation passed.[2] Overall, this literature suggests that non-union firms respond to the threat of unionization by raising wages, a finding consistent with the model presented in this article and with up-to-date estimates of the impact of right-to-work laws provided in Section 5.2.

Other studies have used union densities as measures of the importance of the union threat. Hirsch and Neufeld (1987) find a strong positive relationship between union density and non-union wages. Dickens and Katz (1987) use a principal component analysis to study interindustry wage differences and also find a positive relationship between union coverage and non-union

1. DiNardo and Lee (2004) also discuss how the union threat may contribute to their results.

2. The impact of the right-to-work laws on non-union wages is not reported in Manzo and Bruno (2017) but was communicated to me via private correspondence.

wages. In contrast, Neumark and Wachter (1995) find that an increase in union coverage is linked to lower nonunion wages at the industry level. They, however, find a positive relationship at the city level. In terms of wage dispersion, Kahn and Curme (1987) find a lower non-union wage dispersion in more heavily unionized industries. Foulkes (1980) documents from survey data that, like in the model, large non-union firms increase wages and working conditions pre-emptively to incentivize workers to vote against the formation of a union.

A literature also documents the negative impact of unionization on firm profitability. Lee and Mas (2012) use a regression discontinuity approach to show that, on average, unionization leads to a decline in the firm's equity value of \$40,500 per unionized worker, which translates into a 10% decline in cumulative abnormal stock return. Such an important loss in firm value is indicative of the strong pressure on management to prevent unionization.[3]

Several studies documents that firms employ a wide variety of techniques, legal and illegal, and expand a lot of resources to prevent their own unionization (Dickens, 1983; Freeman and Kleiner, 1990; Bronfenbrenner, 1994). Plenty of anecdotal evidence also show the extent to which some firms are willing to go to avoid unionization. Wal-Mart, the largest employer in the U.S., has been known for its anti-union stance, providing a large amount of support to store managers for that purpose and going as far as shutting down stores after a successful union vote (Vieira, 2014). Recently, several private universities have improved graduate student salaries and benefits substantially in anticipation of a decision by the National Labor Relations Board allowing them to unionize (Elejalde-Ruiz, 2016; Flaherty, 2016).

The next section introduces the model. An explanation of how firms respond to the union threat follows. The model is then calibrated to the U.S. economy and experiments are conducted to evaluate the impact of the union threat. The following section discusses how the model relates to reduced-form estimators commonly used in the literature. The last section concludes.

2. MODEL

This section describes the model. Here is an overview of the main ingredients. The economy is populated by heterogeneous workers and heterogenous firms that meet through frictional labour markets to produce consumption goods. Before production takes place, workers have the option to unionize through a majority election. If the workers unionize, the surplus generated by production is split through a collective bargaining process between the firm and the workers. If instead the union election fails, workers bargain individually with the firm. Because of the difference in bargaining protocol, unionization leads to different wages for the workers and profit levels for the firm.

2.1. *Preferences and technology*

Each worker is endowed with a skill level $s \in \mathcal{S} = \{1,\ldots,S\}$ which remains constant over time. The mass of workers of each skill is given by a vector $\boldsymbol{N} = \{N_s\}_{s\in\mathcal{S}}$, with $N_s > 0$ for all s. Workers live forever, are risk-neutral and discount future consumption at a rate $0 < \gamma < 1$.[4]

3. Lee and Mas (2012) find that this abnormal return is larger in the later part of their sample, from 1984 to 1999, which suggests that the pressure to avoid unionization remained important even under lower unionization rates.

4. Through the article, bold typeface is used to denote vectors.

Each firm is endowed with a technology $j \in \mathcal{J} = \{1, \ldots, J\}$ that converts the labour provided by a vector of workers $\boldsymbol{g} = \{g_s\}_{s \in \mathcal{S}}$ into consumption goods according to the production function

$$F_j(\boldsymbol{g}) = A_j \left(\sum_{s \in \mathcal{S}} z_{j,s} g_s^{\frac{\sigma-1}{\sigma}} \right)^{\frac{\sigma}{\sigma-1}\alpha_j}, \tag{1}$$

where $A_j > 0$ is total factor productivity and $\sigma > 0$ is the elasticity of substitution between skills. The vector $\boldsymbol{z_j} = \left\{z_{j,s}\right\}_{s \in \mathcal{S}}$, with $z_{j,s} > 0$, determines the relative skill intensity in firm j and is normalized to sum to one. The parameter $0 < \alpha_j < 1$ describes the returns to scale of the production function. To keep the exposition simple, labour is the only factor of production in the benchmark model but it is straightforward to also add capital as an additional input, as is done in the quantitative model of Section 4. To avoid cluttering the notation, the subscript j is often omitted when this creates no confusion.

The technology that a firm operates, and in particular the returns to scale parameter α_j and the skill intensity vector $\boldsymbol{z_j}$, will determine its union status in equilibrium. Consider first the role played by α_j. Since firms operate decreasing returns to scale technologies, production involves a fixed factor whose returns, governed by α_j, accrue to the firm owner. When negotiations with the union break down, the firm remains idle and the returns to that fixed factor are lost. Changes in α_j therefore influence the bargaining strength of the union in negotiations with the firm. Another important determinant of the firm's union status is its skill intensity vector $\boldsymbol{z_j}$, which influences how many workers of each skill group the firm hires. Since low-skill workers will tend to vote in favour of unionization while high-skill workers will tend to oppose it, $\boldsymbol{z_j}$ directly influences the outcome of the union vote and how costly it is for the firm to prevent unionization.

2.2. *Labour markets*

The labour market is divided into S submarkets, one for each skill $s \in \mathcal{S}$, in which unemployed workers search for jobs and firms post vacancies. Workers only search in the labour market corresponding to their skill but firms are free to post multiple vacancies in multiple markets, at a unit cost κ. This segmentation of the labour markets by skill groups allows the firm to control precisely the skill composition of its workforce and, through this channel, to influence the union vote.[5]

In a submarket where u unemployed workers are searching and v vacancies are posted, $m(u,v)$ matches are created in a period. The matching function m is assumed to be strictly concave, strictly increasing and homogenous of degree one. By defining the labour market tightness as $\theta = v/u$, the probability that a vacancy is filled can be written as $q(\theta) = m(u,v)/v = m(1/\theta, 1)$, and the probability that an unemployed worker finds a job can be written as $p(\theta) = m(u,v)/u = m(1,\theta)$. Since search requires no effort, all unemployed workers are searching. At the end of each period, a fraction $\delta > 0$ of jobs are exogenously destroyed.

2.3. *Firms*

A firm that previously employed a vector $\boldsymbol{g_{-1}}$ of workers enters the current period with the $(1-\delta)\boldsymbol{g_{-1}}$ workers whose jobs were not randomly destroyed. It can then post a vector of vacancies $\boldsymbol{v} \geq 0$ to maximize its expected discounted profits. Since the firm is posting a continuum of

5. As long as a firm has some control over the type of workers it hires, the threat of unionization will influence its decision. As such, the assumption of perfectly segmented markets is not necessary for the main mechanisms to operate.

vacancies in each labour market, a law of large numbers implies that the mass of successful matches is deterministic.

By defining the current-period profit as $\pi(\boldsymbol{g}) = F(\boldsymbol{g}) - \sum_{s\in\mathcal{S}} w_s(\boldsymbol{g}) g_s$, where $w_s(\boldsymbol{g})$ is the wage of the g_s workers of skill s, we can write the recursive problem of a firm as

$$J(\boldsymbol{g_{-1}}) = \max_{\boldsymbol{v}\geq 0} \pi(\boldsymbol{g}) - \kappa \sum_{s\in\mathcal{S}} v_s + \gamma J(\boldsymbol{g}), \tag{2}$$

subject, for each j, to the law of motion for employment

$$g_s = (1-\delta) g_{-1,s} + v_s q(\theta_s),$$

so that current workers were either with the firm last period or are newly hired.

At a steady state, we can simplify this problem substantially. In this case, the firm has a fraction $1-\delta$ of its optimal employment at the beginning of a period and, because of the linear hiring costs, it immediately hires back to that optimal level. The constraint $\boldsymbol{v} \geq 0$ is therefore never binding and we have the following lemma.

Lemma 1 *In a steady-state equilibrium, the firm's dynamic problem is equivalent to*

$$\max_{\boldsymbol{g}} \pi(\boldsymbol{g}) - \kappa \sum_{s\in\mathcal{S}} \frac{g_s}{q(\theta_s)} + \kappa(1-\delta)\gamma \sum_{s\in\mathcal{S}} \frac{g_s}{q(\theta_s)}. \tag{3}$$

Proof. All the proofs are in the Supplementary Appendix. □

This equation states that a firm sets its employment $\boldsymbol{g}$ to maximize its present-period profit (first term) net of some vacancy posting costs (second term), and taking into account that the $(1-\delta)\boldsymbol{g}$ workers that remains with the firm next period are lowering future hiring costs (last term).

2.4. *Workers*

In each period, a worker is either employed or unemployed. Employed workers lose their jobs with probability δ, in which case they become unemployed. The lifetime discounted expected utility of a worker of type s who is matched with a firm of type j and who is currently earning a wage w is therefore

$$V_{j,s}^E(w) = w + \gamma\left[\delta V_s^U + (1-\delta) V_{j,s}^E(w_{j,s})\right], \tag{4}$$

where V_s^U is the lifetime utility of being unemployed and $w_{j,s}$ is the equilibrium wage that the worker expects to receive next period if there is no job separation. Since wages are bargained every period, the negotiations with the firm are over the current wage w only. Both parties take the future equilibrium wage $w_{j,s}$ as given.

At the beginning of a period, an unemployed worker finds a job with probability $p(\theta_s)$. The expected value of this job is $\mathbb{E}\left(V_{j,s}^E\right)$, where the expectation is taken over all the vacancies, posted by different types of firms, in submarket s. If no job is found, the worker receives home production b_s, which is assumed to be increasing in s. The lifetime discounted utility of an unemployed worker is therefore

$$V_s^U = p(\theta_s)\mathbb{E}\left(V_{j,s}^E\right) + (1-p(\theta_s))\left[b_s + \gamma V_s^U\right]. \tag{5}$$

By combining the last two equations, we can write the gain in utility provided by employment at wage w as

$$V_{j,s}^E(w) - b_s - \gamma V_s^U = w - c_{j,s}, \tag{6}$$

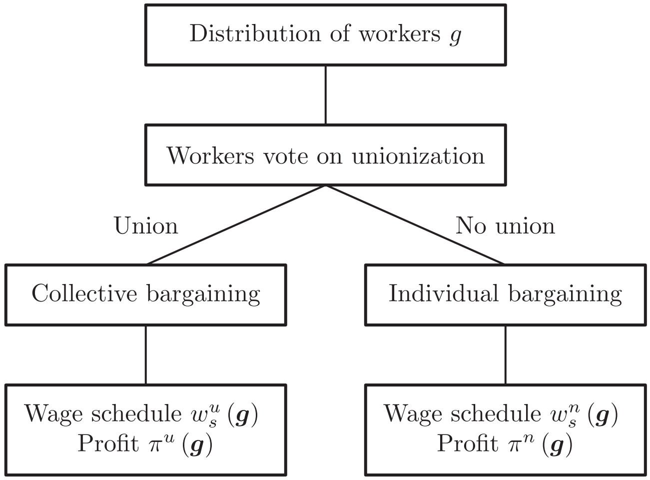

FIGURE 1
Sequence of events after hiring

where

$$c_{j,s} = b_s + \gamma(1-\delta)\frac{(1-\gamma)V_s^U - w_{j,s}}{1-\gamma(1-\delta)} \tag{7}$$

is the net outside option of a worker s who is bargaining with a firm j. This convenient notation makes explicit the fact that the worker loses all potential future wages $w_{j,s}$ if the bargaining breaks down.

2.5. *Wages*

In the U.S., the typical unionization process starts when a group of workers petition the National Labor Relation Board (NLRB) for a union recognition. If there is sufficient interest from employees, the NLRB makes a ruling on whether the workers that would be covered by the union share a "community of interest." In practice, the coverage of the union is often at the enterprise level (Traxler, 1994; Nickell and Layard, 1999).[6] Then, the NLRB organizes a vote at the work site and a simple majority is required for the union to be certified as the exclusive bargaining agent of the workers. All work-related negotiations between the workers and the firm must then be conducted by the union.

The model incorporates these features of the institutional environment. The sequence of events that occurs once a firm has hired its new workers is shown in Figure 1. First, the workers vote to decide whether to form a union or not. Then, if the union vote is successful, wages are bargained *collectively*. The outcome of this bargaining is a wage schedule $\boldsymbol{w^u}(\boldsymbol{g})$ and a profit function $\pi^u(\boldsymbol{g})$. Instead, if the union vote fails to gather enough support, wages are bargained *individually*, which leads to a wage schedule $\boldsymbol{w^n}(\boldsymbol{g})$ and a profit function $\pi^n(\boldsymbol{g})$. Unionization is therefore a way for the workers to force the firm into a different wage setting mechanism.

Both individual and collective bargaining are modelled using Nash bargaining, but the surplus that is bargained over is different. In a union firm, the workers and the firm bargain collectively

6. The bulk of the literature models unions at the level of the production function. For recent examples, see Ebell and Haefke (2006) and Dinlersoz and Greenwood (2016).

over the *total* surplus generated by all the workers. If an agreement on wages cannot be reached, the whole workforce leaves the firm and no production takes place. In a non-union firm, each worker bargains individually with the firm over the *marginal* surplus he or she alone generates. If the bargaining fails, this specific worker goes to unemployment but the firm can still produce with the remaining workers. As we will see, this asymmetry between collective and individual bargaining interacts with the decreasing returns of the production function and has important consequences for profits and wages. It is the only difference between a union and a non-union firm in the model.

2.5.1. Collective bargaining.

Collective bargaining is modelled as an n-player Nash (1950) bargaining between the firm and all its workers.[7] If an agreement on a wage schedule $\boldsymbol{w}$ is reached, a worker s receives $V_s^E(w_s)$, otherwise he or she receives home production b_s today and starts the next period as unemployed, which has value γV_s^U. The net benefit of an agreement to a worker is therefore $V_s^E(\boldsymbol{w})-b_s-\gamma V_s^U$. On the firm side, if an agreement is reached production takes place and wages are paid. Otherwise, the firm loses all its workers and needs to hire extensively next period to get back to its optimal size.

The following lemma formalizes this collective bargaining problem.

Lemma 2 *If all the workers have the same bargaining power, and the firm has bargaining power $1-\beta_u$, the collective Nash bargaining problem can be written as*

$$\max_{\boldsymbol{w}}\left[\prod_{s\in\mathcal{S}}\left(V_s^e(\boldsymbol{w})-b_s-\gamma V_s^U\right)^{\frac{g_s}{n}}\right]^{\beta_u}\left[F(\boldsymbol{g})-\sum_{s\in\mathcal{S}}w_sg_s+(1-\delta)\kappa\gamma\sum_{s\in\mathcal{S}}\frac{g_s}{q(\theta_s)}\right]^{1-\beta_u}, \tag{8}$$

where $n=\sum_{s\in\mathcal{S}}g_s$ is the total mass of employed workers. Furthermore, the wage schedule

$$w_s^u(\boldsymbol{g})-c_s=\frac{\beta_u}{n}\left(F(\boldsymbol{g})-\sum_{k\in\mathcal{S}}c_kg_k+\gamma(1-\delta)\kappa\sum_{k\in\mathcal{S}}\frac{g_k}{q(\theta_k)}\right) \tag{9}$$

solves this bargaining problem.

This collective bargaining problem is very similar to the usual 2-player bargaining. The first term between brackets in (8) can be interpreted as the surplus of the union; it takes the simple form of a geometric average of all the workers' individual surpluses. The second term between brackets is the surplus of the firm. Its interpretation is straightforward: if negotiations break down, the firm loses the current-period profit and pays a higher hiring cost tomorrow to compensate for the loss of the fraction $1-\delta$ of its current workforce that would have remained next period if negotiations had been successful.

From (9), it is straightforward to compute the current-period profit of a union firm employing workers $\boldsymbol{g}$ as

$$\pi^u(\boldsymbol{g})=(1-\beta_u)F(\boldsymbol{g})-(1-\beta_u)\sum_{s\in\mathcal{S}}c_sg_s-\beta_u(1-\delta)\kappa\gamma\sum_{s\in\mathcal{S}}\frac{g_s}{q(\theta_s)}, \tag{10}$$

where c_s is given by (7).

7. Nash bargaining with more than two players is microfounded in axiomatic bargaining theory (Roth, 1979) and in game theory (Krishna and Serrano, 1996).

Other works in the literature also rely on some form of Nash-bargaining to model wage setting in union firms (Bauer and Lingens, 2010; Açikgöz and Kaymak, 2014). In general, the literature assumes that the firm enters a 2-player bargaining problem with some separate organization referred to as a union. Importantly, to properly define the bargaining problem the union must be endowed with its own preferences. In contrast, in the current model a union is simply the collective of the workers who are entering the n-person Nash bargaining with the firm. Each agent uses his or her own preferences, and there is no need to model a union as a separate middleman between the workers and the firm. As a result, here, the "preferences of the union" are microfounded directly from the preferences of the individual workers.[8]

2.5.2. Individual bargaining. If, instead, the union fails to gather a majority of the votes, each worker bargains individually with the firm. In this case, the firm compares producing with and without that worker. Importantly, it understands that if that worker leaves, the marginal product of the remaining workers might change. In this case, these workers may want to reopen negotiations with the firm.[9]

In this context, the firm's marginal gain from employing an extra worker of type s is

$$\Delta_s^n(\boldsymbol{w}) = \frac{\partial F(\boldsymbol{g})}{\partial g_s} - w_s(\boldsymbol{g}) - \sum_{k \in \mathcal{S}} g_k \frac{\partial w_k(\boldsymbol{g})}{\partial g_s} + \gamma(1-\delta)\frac{\kappa}{q(\theta_s)}.$$

The first term is the extra output produced by the worker. The next term is simply the wage paid to the worker. The third term is the marginal effect of this worker on the wage of the other members of the workforce. Finally, the last term is the expected vacancy costs saved from retaining, with probability $1-\delta$, this worker into the next period.

Defining $0<\beta_n<1$ as the bargaining power of a nonunion worker, Nash bargaining implies that the non-union wage vector $\boldsymbol{w}$ must solve the system of partial differential equations

$$\beta_n \Delta_s^n(\boldsymbol{w}) = (1-\beta_n)\left(V_s^E(\boldsymbol{w}) - b_s - \gamma V_s^U\right) \tag{11}$$

for all $s \in \mathcal{S}$ with the standard boundary conditions $\lim_{g_s \to 0} w_s^n(\boldsymbol{g}) g_s = 0$ for all $s \in \mathcal{S}$.

The solution to this system is characterized in the following lemma.

Lemma 3 *The wage schedule*

$$w_s^n(\boldsymbol{g}) - c_s = \frac{\beta_n}{1-(1-\alpha)\beta_n} \frac{\partial F(\boldsymbol{g})}{\partial g_s} - \beta_n c_s + \beta_n \gamma(1-\delta)\frac{\kappa}{q(\theta_s)} \tag{12}$$

solves the individual bargaining problem (11).

8. The literature generally assumes that the union maximizes the sum of the surplus going to the workers. With risk-neutral heterogenous workers, this assumption only pins down the total share of the surplus going to the workers, not how it is divided among them. In contrast, the current modelling assumption pins down what each worker receives. Another advantage of this approach is that it is robust in the sense that other bargaining environments yield the same outcome. For instance, Supplementary Appendix E.2 shows that introducing a union organization between the workers and the firms leaves the wage equation (9) unchanged if the workers bargain collectively with the union.

9. Stole and Zwiebel (1996) and Brügemann *et al.* (2019) provide theoretical foundations for this type of bargaining. Bertola and Garibaldi (2001) show that this bargaining procedure is broadly consistent with the empirical "relationship between employer size, the mean and variance of employees' wages, and the character of gross job creation and destruction." See also Cahuc and Wasmer (2001), Elsby and Michaels (2013), and Acemoglu and Hawkins (2014) for search models using this bargaining protocol. Supplementary Appendix E.1 shows that the key mechanisms are preserved in an alternative model in which firms can pick non-union wages unilaterally instead of through individual bargaining.

It follows directly that the current-period profit of a non-union firm is

$$\pi^n(\boldsymbol{g}) = \frac{1-\beta_n}{1-(1-\alpha)\beta_n} F(\boldsymbol{g}) - (1-\beta_n)\sum_{s\in\mathcal{S}} c_s g_s - \beta_n(1-\delta)\kappa\gamma \sum_{s\in\mathcal{S}} \frac{g_s}{q(\theta_s)}. \tag{13}$$

2.5.3. Comparing collective and individual bargaining. The wage equations (9) and (12) derived from the collective and the individual bargaining problems have remarkably similar structures. They each consist of three terms that relate to production, the outside option of the workers and the hiring costs paid by the firm. They, however, differ in how these quantities influence wages. Indeed, the union wage (9) is mostly a function of the *average* characteristics of the workers, while the non-union wage (12) is a function of the *individual* characteristics of each worker. In particular, the union wage of a worker of skill s depends on the average product $F(\boldsymbol{g})/n$ of all the workers in the firm while their non-union wage is a function of the marginal product $\partial F(\boldsymbol{g})/\partial g_s$ of that worker alone.

This asymmetry has two important consequences. First, the presence of a union influences wage inequality within the firm, with union wages being naturally compressed. Second, the possibility of unionization creates a conflict between workers of different skills. Workers with valuable characteristics, for instance high marginal products, would rather bargain individually with the firm than share their high productivity with the other employees. As a result, high-skill workers are more likely to be against unionization than low-skill ones.[10]

The following proposition shows that unionization also creates a second conflict, this time between the firm and the workers.

Proposition 1 *If the bargaining powers are equal ($\beta = \beta_n = \beta_u$), the difference between the average non-union and union wage is*

$$\mathbb{E}_s\left(\boldsymbol{w^n}(\boldsymbol{g})\right) - \mathbb{E}_s\left(\boldsymbol{w^u}(\boldsymbol{g})\right) = -\frac{\beta(1-\beta)(1-\alpha)}{1-(1-\alpha)\beta}\frac{F(\boldsymbol{g})}{n} < 0,$$

where $\mathbb{E}_s$ is the expectation across skills. It follows that the difference between non-union and union profits is

$$\pi^n(\boldsymbol{g}) - \pi^u(\boldsymbol{g}) = \frac{\beta(1-\beta)(1-\alpha)}{1-(1-\alpha)\beta} F(\boldsymbol{g}) > 0.$$

This proposition shows that, for any set of workers $\boldsymbol{g}$, a firm prefers to bargain individually, while the workers, on average, would rather bargain collectively. This conflict between the workers and the firm is a direct consequence of the decreasing returns to scale in production. Indeed, as $\alpha \to 1$ the differences in profits and in average wages go to zero. To understand why, consider that when bargaining individually, the firm contemplates producing with or without the *marginal* worker. Because of diminishing returns to labour, this marginal worker has a relatively small impact on total production, limiting their possibility to bargain. The firm can then extract a large share of the total surplus. On the other hand, when the firm bargains with the union, the surplus is a function of the *total* production, which includes the relatively high output generated by the infra-marginal workers. By forming a union, the workers can thus extract a bigger share of these high marginal products, which lowers the firm's profit.[11]

10. Verna (2005) discusses the literature on the relationship between worker productivity and pay in union firms. Consistent with the theory, pay is more correlated with ability and performance in non-union firms.

11. Proposition 1 is consistent with evidence from Kleiner (2001) showing that firms generally oppose unions. Freeman and Kleiner (1990) and Bronfenbrenner (1994) also detail various tactics used by firms to prevent unionization.

While Proposition 1 compares wages and profits when β_u and β_n are equal, the conflict between the workers and the firm naturally becomes more severe as β_u increases or β_n falls. In these cases, the workers are more strongly in favour of unionization while the firm's preference for remaining union free grows. As a result, workers are more likely to vote in favour of unionization and it becomes harder for the firm to incentives them otherwise. Together, the parameters α, β_u, and β_n are therefore key determinants of the strength of the threat of unionization that the firm is facing.

2.6. *Voting procedure*

When the union vote takes place, workers know the wages they will get after either outcome of the vote, and the difference between these wages is the key driver of how they will vote. In addition, workers might favour or oppose unions for reasons unrelated to wages. For instance, workers with different political views might vote differently even if they face the same union and non-union wages. To capture these additional voting motives, I assume that a worker of skill s votes for the union if and only if $w_s^u(\boldsymbol{g}) - w_s^n(\boldsymbol{g}) > \varepsilon$, where ε is a random variable with mean 0 that is drawn independently across workers in each period and that has a CDF ϕ with $\phi(0) = 1/2$.[12]

Since the firm employs a continuum of workers of each skill, a law of large numbers applies and a deterministic fraction $\phi\left(w_s^u(\boldsymbol{g}) - w_s^n(\boldsymbol{g})\right)$ of workers of type s votes for unionization. Denoting by

$$\Lambda(\boldsymbol{g}) = \sum_{s \in \mathcal{S}} g_s \phi\left(w_s^u(\boldsymbol{g}) - w_s^n(\boldsymbol{g})\right) - \frac{1}{2} n \tag{14}$$

the excess number of workers in favour of unionization, a firm is unionized if and only if $\Lambda(\boldsymbol{g}) > 0$. Notice that the outcome of the vote is deterministic and that the firm therefore knows whether a union will be formed when it decides which workers to hire. As a result, the firm is effectively deciding its union status.

2.7. *Steady-state equilibrium*

In a steady state, the flows in and out of unemployment in each labour market must be equal. In submarket s, this implies the following relationship between the mass u_s of job searchers and the labour market tightness θ_s:

$$u_s = \frac{\delta(1 - p(\theta_s))}{\delta + p(\theta_s)(1 - \delta)}. \tag{15}$$

We can now define a steady-state equilibrium in this economy.

Definition 1 *A steady-state equilibrium is, a set of value functions $\left\{V_{j,s}^E, V_s^U\right\}_{s \in \mathcal{S}, j \in \mathcal{J}}$, labour market tightnesses $\{\theta_s\}_{s \in \mathcal{S}}$, employment vectors $\left\{g_s^j\right\}_{s \in \mathcal{S}, j \in \mathcal{J}}$, and wage schedules $\left\{w_s^j\right\}_{s \in \mathcal{S}, j \in \mathcal{J}}$ such that,*

1. the workers' value functions (4) and (5) are satisfied;

Hirsch (2004) summarizes the literature on union and profitability and concludes that union firms are in general less profitable than firms that are not unionized.

12. This random disutility term is not necessary for the results but helps to convexify the firm's optimization problem so that standard algorithms can be used to solve that problem easily. An earlier version of the model assumed no random preferences for unionization and found similar quantitative results.

2. the employment vectors $\left\{g_s^j\right\}_{s\in\mathcal{S},j\in\mathcal{J}}$ solve the optimization problem of the firms given by (3) and where $\boldsymbol{w}(\boldsymbol{g})$ is given by (12) if $\Lambda_j(\boldsymbol{g})\leq 0$ or (9) otherwise;
3. the labour market tightnesses $\{\theta_s\}_{s\in\mathcal{S}}$ are consistent with stationarity (15) and with the hiring decisions of the firms, *i.e.*, total vacancy posting in each submarket $s\in\mathcal{S}$ is $v_s=\sum_{j\in\mathcal{J}}\delta g_s^j/q(\theta_s)$.

3. ECONOMIC FORCES AT WORK

We now investigate how the union threat influences the hiring decisions of a firm. As shown in Lemma 1, at a steady state, a firm's optimal employment decision solves

$$\max_{\boldsymbol{g}}\Pi(\boldsymbol{g},\boldsymbol{w}(\boldsymbol{g})), \tag{16}$$

where the objective function Π is defined as

$$\Pi(\boldsymbol{g},\boldsymbol{w}(\boldsymbol{g}))=F(\boldsymbol{g})-\sum_{s\in\mathcal{S}}g_s w_s(\boldsymbol{g})-\kappa(1-(1-\delta)\gamma)\sum_{s\in\mathcal{S}}\frac{g_s}{q(\theta_s)},$$

and where the wage schedule $\boldsymbol{w}$ is given by

$$\boldsymbol{w}(\boldsymbol{g})=\begin{cases}\boldsymbol{w^u}(\boldsymbol{g}) & \text{if } \Lambda(\boldsymbol{g})>0 \quad \text{(the union vote succeeds)}\\ \boldsymbol{w^n}(\boldsymbol{g}) & \text{if } \Lambda(\boldsymbol{g})\leq 0. \qquad \text{(the union vote fails)}\end{cases}$$

In an economy in which unions are weak, perhaps because of a low bargaining power β_u, firms do not have to worry about unionization. They simply hire to maximize discounted profits under the non-union wage schedule $\boldsymbol{w^n}(\boldsymbol{g})$. Denote this optimal hiring decision by $\boldsymbol{g^{n*}}=\operatorname{argmax}_{\boldsymbol{g}}\Pi(\boldsymbol{g},w^n(\boldsymbol{g}))$.

As the strength of unions increases, unionization becomes more attractive to the workers. If the firm keeps hiring according to $\boldsymbol{g^{n*}}$, there comes a point at which a majority of the workers will vote for unionization. The firm is then *constrained* by the unionization vote, and hiring according to $\boldsymbol{g^{n*}}$ is no longer optimal. In that situation, the firm modifies its hiring so that the workers reject the union. This new hiring decision, denoted by $\boldsymbol{g^n}$, maximizes $\Pi\left(\boldsymbol{g},\boldsymbol{w^n}(\boldsymbol{g})\right)$ subject to the constraint that workers vote against the union, *i.e.*, $\Lambda(\boldsymbol{g})\leq 0$. Through this additional constraint, the hiring decisions of firms that are union free in equilibrium, as well as the wages they pay, are affected by the workers' option to unionize.

If the strength of unions increases even more, the firm contemplates letting its workers unionize. In this case, its profits would be $\Pi\left(\boldsymbol{g^{u*}},\boldsymbol{w^u}\left(\boldsymbol{g^{u*}}\right)\right)$, where $\boldsymbol{g^{u*}}$ is the optimal employment vector under collective bargaining. If preventing unionization is so costly that $\Pi\left(\boldsymbol{g^{u*}},\boldsymbol{w^u}\left(\boldsymbol{g^{u*}}\right)\right)>\Pi\left(\boldsymbol{g^n},\boldsymbol{w^n}\left(\boldsymbol{g^n}\right)\right)$, the firm chooses to be unionized as an optimal reaction to the threat of unionization.[13]

To understand how the threat affects decisions, it is useful to first consider an equilibrium in which the union status of the firms is given exogenously, such that no union vote takes place. In this case, we can characterize how a firm hires, the wages it pays as well as the workers' preference for unionization. We then take a step back and consider the full problem of a firm when unionization is endogenous—where the union threat matters. To focus the analysis on the empirically relevant cases, assume from now on that the value of unemployment W_s^u and the labour market tightness θ_s are increasing in s. These assumptions are satisfied in the calibrated economy presented in the next section.

13. It is possible to build examples in which $\Lambda(\boldsymbol{g^{u*}})<0$ but this usually requires extreme parameters.

3.1. *Exogenous union status*

We first consider the problem of a firm whose union status is exogenously given, such that the union threat has no impact on its behaviour. This firm maximizes profits $\Pi\left(\boldsymbol{g}, w^i(\boldsymbol{g})\right)$ where the superscript i indicates whether the firm is unionized ($i=u$) or not ($i=n$). By defining

$$\mathrm{MC}_s^i = (1-\beta_i)c_s + (1-\gamma(1-\delta)(1-\beta_i))\frac{\kappa}{q(\theta_s)} \tag{17}$$

as the marginal cost paid to hire a worker of skill s, the firm's optimal hiring decision $\boldsymbol{g^{i*}}$ solves

$$\mathrm{MC}_s^i = B_i \frac{\partial F(\boldsymbol{g})}{\partial g_s}, \tag{18}$$

where

$$B_i = \begin{cases} 1-\beta_u & \text{if } i=u \\ \frac{1-\beta_n}{1-(1-\alpha)\beta_n} & \text{if } i=n \end{cases}$$

is the share of revenues retained by the firm after bargaining. Equation (18) simply states that at the optimum the marginal revenue generated by an extra worker of type s is equal to the marginal cost of hiring that worker.

Solving (18), the optimal hiring decision g^{i*} is

$$g_s^{i*} = (\alpha A B_i)^{\frac{1}{1-\alpha}} \left(\frac{z_s}{\mathrm{MC}_s^i}\right)^{\sigma} \left(\sum_{k\in\mathcal{S}} z_k \left(\frac{z_k}{\mathrm{MC}_k^i}\right)^{\sigma-1}\right)^{\frac{1-\sigma(1-\alpha)}{(\sigma-1)(1-\alpha)}} \tag{19}$$

which, together with (17), shows that workers who search in tight labour markets (θ_s large) or who have attractive outside options (c_s large) are expensive to hire (MC_s^i large), and that the firm therefore relies less on them for production (g_s^{i*} small). When bargaining powers are equal, non-union firms are also larger than union firms (since $B_n > B_u$) as they tend to hire more workers to lower their marginal products and thus pay lower wages.

The following proposition characterizes the wages paid by the firms.

Proposition 2 *The equilibrium wage schedules $w_s^u\left(\boldsymbol{g^{u*}}\right)$ and $w_s^n\left(\boldsymbol{g^{n*}}\right)$ are increasing in skill s, and the union wage gap $w_s^u\left(\boldsymbol{g^{u*}}\right) - w_s^n\left(\boldsymbol{g^{n*}}\right)$ is decreasing in s.*

This proposition is consistent with a large empirical literature that finds that the union wage gap in the U.S. declines with income (Card, 1996; Card *et al.*, 2004). It characterizes the *observed* wages that are paid in equilibrium, but not the workers' preferences about unionization. For those, we need to consider the counterfactual wages that the workers would receive if the union status of their firm were to change.

Proposition 3 *The counterfactual union wage gap $w_s^u\left(\boldsymbol{g^{i*}}\right) - w_s^n\left(\boldsymbol{g^{i*}}\right)$ is decreasing in skill s for both firm union status $i\in\{u,n\}$.*

Proposition 3 characterizes the counterfactual, unobserved union wage gap that workers consider when casting their vote. It is consistent with work by Farber and Saks (1980), who show that the desire of a worker to be unionized goes down with her position in the intra-firm earnings distribution.

Propositions 2 and 3 are direct consequences of the individual and collective bargaining protocol outlined earlier. As individually bargained wages depend more on a worker's own characteristics, they tend to favour high-skill workers at the expense of low-skill workers.

3.2. *Preventing unionization*

We now consider the problem of a firm whose union status is endogenously determined by the vote of its workers. To maximize profits, the firm compares the optimal employment decision under which the workers unionize, $\boldsymbol{g^{u*}}$, to the optimal employment decision under which the workers reject the union, $\boldsymbol{g^n}$. In the latter case, the firm takes the voting constraint $\Lambda(\boldsymbol{g}) \leq 0$ into consideration such that $\boldsymbol{g^n}$ solves a modified version of the first-order conditions (18) that takes into account the impact of the marginal worker on the union vote. The new conditions are, for all $s \in \mathcal{S}$,

$$\mathrm{MC}_s^n + \lambda \frac{\partial \Lambda\left(\boldsymbol{g^n}\right)}{\partial g_s} = B_n \frac{\partial F\left(\boldsymbol{g^n}\right)}{\partial g_s}, \tag{20}$$

where $\lambda \geq 0$ is the Lagrange multiplier associated with the voting constraint $\Lambda(\boldsymbol{g}) \leq 0$. We see that this constraint effectively increases the marginal cost of hiring a worker who votes for the union.

We can expand the derivative of the voting constraint as follows:

$$\frac{\partial \Lambda(\boldsymbol{g})}{\partial g_s} = \underbrace{\phi(\Delta_s(\boldsymbol{g})) - \frac{1}{2}}_{\text{(a)}} + \underbrace{\sum_{s' \in \mathcal{S}} g_{s'} \frac{\partial \Delta_{s'}(\boldsymbol{g})}{\partial g_s} \frac{\partial \phi(\Delta_{s'}(\boldsymbol{g}))}{\partial \Delta_{s'}(\boldsymbol{g})}}_{\text{(b)}}, \tag{21}$$

where $\Delta_s(\boldsymbol{g}) = w_s^u(\boldsymbol{g}) - w_s^n(\boldsymbol{g})$ is the counterfactual union wage gap and where $\phi(\Delta_s)$ is, as before, the fraction of workers of skill s who vote for the union when the wage gap that they face is Δ_s. The terms (a) and (b) in (21) highlight two mechanisms through which hiring a worker of skill s influences the union vote.

(a) Direct impact on voting. As a fraction $\phi(\Delta_s)$ of workers of skill s vote in favour of the union, adding an extra worker of this type directly increases the excess number of voters in favour of unionization by $\phi(\Delta_s) - 1/2$.

(b) Indirect effect through wages. An extra hire of skill s also affects the union wage gap of the other workers in the firm ($\partial \Delta_{s'}/\partial g_s$) which, in turn, influences how they vote ($\partial \phi_{s'}/\partial \Delta_{s'}$). For instance, hiring an additional worker of skill s lowers the marginal product of all skill s workers. As a result, their non-union wage also declines and, through this channel, these workers are more likely to vote for the union. An extra hire also changes union wages throughout the firm. Since union wages are driven by the average product, hiring a high-s worker shifts the union wage schedule upward which helps the union. If instead the firm hires many low-skill workers, their relatively low marginal product pushes the union wage schedule downward, which increases the number of votes against unionization.

To prevent unionization, the firm takes both of these channels into account. Channel (a), as it directly affects the union vote, is particularly important and is used by firms to their advantage. It pushes them to hire more high-skill workers, who vote against the union, and fewer low-skill workers, who vote in its favour. These changes in hiring then affect the wages paid by the firms.

3.2.1. Simplified economy. In general, the problem of a firm constrained by the union vote must be solved numerically. We can however derive some analytical results in a static ($\gamma = 0$) economy in which there are only two types of workers (high-skill h and low-skill l) and in which workers have no random disutility from unionization ($\varepsilon = 0$). For tractability, assume also that the firm combines labour inputs using a Cobb–Douglas technology ($\sigma = 1$) and that there is no home production ($b_s = 0$ for all $s \in \mathcal{S}$).[14]

For the union threat to have an impact on the behaviour of the firms, I also assume that the following assumption holds throughout this section.

Assumption 1 *$0 < B_u < B_n < 1$, $z_h q(\theta_h) < z_l q(\theta_l)$ and $z_h \geq z_l$.*

The first part of Assumption 1, $B_n > B_u$, implies that workers, as a group, prefer to be unionized. The second part, $z_h q(\theta_h) < z_l q(\theta_l)$, guarantees that the firm would hire more low-skill than high-skill workers in an environment without the voting constraint. The third part of the assumption, $z_h \geq z_l$, implies that, all else equal, high-skill workers are more productive than low-skill workers.

The following proposition establishes that the union threat influences the behaviour of non-union firms in this environment.

Proposition 4 *The union threat is binding for non-union firms, i.e., $\Lambda(\boldsymbol{g}) = 0$.*

Under the conditions of Assumption 1, low-skill workers have the majority of the votes in the union election. As these workers vote in favour of the union, the firm must distort its hiring decision, from $\boldsymbol{g}^{\boldsymbol{n}*}$ to $\boldsymbol{g}^{\boldsymbol{n}}$, to prevent unionization. The firm does so by over-hiring high-skill workers and under-hiring low-skill workers. The following proposition highlights the impact of this change in hiring on the size and profits of the firm.

Proposition 5 *The union threat lowers the profits, employment, and output of non-union firms.*

Intuitively, the voting constraint $\Lambda(\boldsymbol{g}) \leq 0$ distracts the firm from maximizing the production surplus and pushes it to use an inefficient mix of workers. As a result, the unit cost of production increases, which leads the firm to hire fewer workers to take advantage of the steeper part of the production function, and output declines.

The threat also affects wages, as the following proposition shows.

Proposition 6 *The union threat increases the average wage and decreases wage inequality, defined as the ratio of high-skill to low-skill wages, in non-union firms.*

As the firm reduces its size in response to the threat, the average marginal product of the workers increases, which pushes wages higher. In addition, since the firm now hires a higher ratio of high-skill to low-skill workers, the marginal product—and therefore the wage—of high-skill workers falls relative to that of low-skill workers. As a result, wage inequality decreases when a firm is subject to the threat.

We can also use this simplified model to shed light on which type of firms are more likely to be unionized. For that purpose, it is useful to define $\Delta\Pi = \Pi(\boldsymbol{g}^{\boldsymbol{n}}) / \Pi(\boldsymbol{g}^{\boldsymbol{u}*})$ as the ratio of a firm's profits if it successfully prevents unionization, $\Pi(\boldsymbol{g}^{\boldsymbol{n}})$, to its profits if its workers unionize,

14. Supplementary Appendix A provides a numerical example of the behaviour of a firm under threat in an economy with a full distribution of skills.

$\Pi\left(\boldsymbol{g}^{\boldsymbol{u}*}\right)$. $\Delta\Pi$ therefore provides a natural measure of the gain in profitability associated with preventing unionization. In particular, if $\Delta\Pi < 1$ the firm optimally decides to become unionized.

The following proposition highlights how firms with different skill intensity vectors respond to the threat.

Proposition 7 *$\Delta\Pi$ is maximized when worker heterogeneity is minimal, in the sense that $z_l q(\theta_l) = z_h q(\theta_h)$.*

The intuition for this result is straightforward. The term $z_s q(\theta_s)$—the product of the intensity z_s of skill s in production with the inverse of a measure of how expensive these workers are to hire—captures how many workers of type s a firm wants to hire when it is unconstrained. If $z_l q(\theta_l)$ and $z_h q(\theta_h)$ are close to each other, the firm prefers to hire a similar number of workers of each skill. Under these circumstances, if the firm becomes subject to the voting constraint, it only needs to hire a few additional high-skill workers and a few less low-skill workers to prevent unionization. The distortion created by the constraint is therefore small and so is the loss in profits from preventing unionization. As the gap between $z_l q(\theta_l)$ and $z_h q(\theta_h)$ widens, the firm must depart more substantially from its optimal unconstrained skill mix and it becomes more costly to win the union vote.

A firm's labour intensity α also matters for its union status, as the following proposition shows.

Proposition 8 *There is a threshold $\bar{\alpha} \in [0,1]$ such that $\Delta\Pi > 1$ for $\alpha < \bar{\alpha}$ and $\Delta\Pi < 1$ for $\alpha > \bar{\alpha}$. In addition, there is a threshold $\hat{\alpha} \in [0,1]$ such that the firm cannot prevent unionization if $\alpha < \hat{\alpha}$.*

This result comes directly from the difference in bargaining protocol, and is reminiscent of Proposition 1. As the labour intensity α gets smaller, individual bargaining becomes increasingly attractive to the firm and, at some point, preventing unionization becomes profitable. The second part of Proposition 8 shows, however, that the firm might not be able to prevent unionization. For labour intensities below $\hat{\alpha}$, the gains in wages from unionization are so large that the workers vote for the union no matter what.[15]

Together, Propositions 4 and 8 show that, in this simple economy, firms with labour intensities in the interval $\alpha \in \left[\hat{\alpha}, \bar{\alpha}\right]$ would have their decisions affected by the threat of unionization while remaining union free. If the distribution of labour intensities has full support, a strictly positive mass of non-union firms would therefore be affected. This last result shows that the threat of unionization can affect not only firms that are at the margin of being unionized, but also those for which unionization might seem a more distant prospect.

In addition to α and $\boldsymbol{z}$, the bargaining powers matter for whether the firm manages to prevent unionization, as the following proposition shows.

Proposition 9 *There are thresholds $\bar{\beta}_u \in [0,1]$ and $\bar{\beta}_n \in [0,1]$ such that the firm cannot prevent unionization if $\beta_u > \bar{\beta}_u$ or if $\beta_n < \bar{\beta}_n$.*

15. The firm prevents unionization by hiring more high-skill workers and fewer low-skill workers. If $\alpha < \hat{\alpha}$, the firm will reach a point at which the non-union wage of the high skill workers $w_s^n(g^n)$ is equal to their counterfactual union wage $w_s^u(g^n)$ while the low-skill workers still have a majority of the vote $g_l^n > g_h^n$. In this case, adding an extra high-skill worker would push their non-union wage $w_s^n(g^n)$ under $w_s^u(g^n)$ and they would vote for the union. Removing a low-skill worker would push the union wage of the high skill workers $w_s^u(g^n)$ above their non-union wage $w_s^n(g^n)$ and they would also vote for the union.

The bargaining powers β_n and β_u are key determinants of the strength of the union threat and, as such, influence whether the firm can prevent unionization. For instance, if β_u is large enough, union wages are so high that the firm cannot incentive the workers to vote against the union no matter what. Similarly, if β_n is small enough, non-union wages are low and unionization is too attractive a prospect for the workers to vote against it.

3.3. *Impact of the threat on social welfare*

The threat of unionization also affects welfare by distorting the type of workers that the firm hires. To highlight the mechanisms at work, it is useful to consider the problem of a social planner that seeks to maximize steady-state welfare in this economy. To keep the analysis, tractable I assume here that all jobs are destroyed at the end of a period ($\delta = 1$).

The planner's problem involves choosing the employment of all skill levels $s \in \mathcal{S}$ in all firms $j \in \mathcal{J}$ to maximize the social welfare function

$$\sum_{j \in \mathcal{J}} \left[F_j(\boldsymbol{g_j}) + \sum_{s \in \mathcal{S}} (N_s - g_{j,s}) b_s - \sum_{s \in \mathcal{S}} g_{j,s} \frac{\kappa}{q(\theta_s)} \right], \tag{22}$$

where N_s denotes, as before, the total mass of agents s in the economy.[16,17] The first term is the total amount of output produced, the second term is the home production of the unemployed, and the last term corresponds to the costs that must be paid to hire the workers. The planner maximizes (22) subject to the constraint that the flows in and out of the labour market must equal each other at a steady state, *i.e.*, (15) must be satisfied. Taking first-order conditions and simplifying, one can show that the planner's chosen allocation must satisfy

$$\frac{\partial F_j}{\partial g_{j,s}} - b_s - \frac{\kappa}{p'(\theta_s)} = 0 \tag{23}$$

for all $s \in \mathcal{S}$ and all $j \in \mathcal{J}$. Notice that the union status of the firm does not show up in (23). Indeed, unionization, on its own, only affects how the surplus from production is split between the workers and the firm. It does not affect how big that surplus is, which is what the planner cares about.

We can compare this equation to its equivalent in the decentralized equilibrium. Under our assumption that $\delta = 1$, the first-order condition (20) for hiring workers of skill s in a non-union firm j becomes

$$\frac{1-\beta_n}{1-(1-\alpha)\beta_n} \frac{\partial F_j}{\partial g_{j,s}} - (1-\beta_n) b_s - \frac{\kappa}{q(\theta_s)} - \lambda_j \frac{\partial \Lambda(g_j)}{\partial g_{j,s}} = 0, \tag{24}$$

where, as before, $\lambda_j > 0$ is the Lagrange multiplier associated with the union vote constraint $\Lambda(\boldsymbol{g}) \leq 0$. Similarly, the first-order condition for a union firm j hiring a worker s is

$$(1-\beta_u) \frac{\partial F_j}{\partial g_{j,s}} - (1-\beta_u) b_s - \frac{\kappa}{q(\theta_s)} = 0. \tag{25}$$

Contrasting the equilibrium conditions (24) and (25) with the planner's allocation (23) reveals three sources of inefficiency in this economy. First, by comparing (23) and (25), we see that the

16. Since all agents are risk-neutral, the planner can simply maximize total production in that economy and then use lump-sum transfers to redistribute that production among agents.

17. Lemma A.1 in the Supplementary Appendix shows that we can normalize the mass of each firm to 1 by adjusting their total factor productivity A_j.

employment decisions of a union firm coincide with those of the social planner when $\beta_u = -\theta q'(\theta)/q(\theta)$, which is the standard Hosios (1990) condition for efficiency in random search models. Under that condition, a fully unionized economy would be efficient. The second source of inefficiency comes from the individual bargaining protocol. By comparing (23) and (24), we see that even if the threat of unionization is inactive $\left(\lambda_j = 0\right)$, there is no condition like Hosios' that would make these two equations coincide. Under individual bargaining, the firm seeks to lower wages by over-hiring workers compared to what is socially optimal (Stole and Zwiebel, 1996). Finally, the threat of unionization ($\lambda_j > 0$) creates a third source of inefficiency. As we can see by comparing (23) and (24), it creates an additional wedge that leads to misallocation of employment across skill groups. Since high-skill workers vote against unionization, the threatened firms hire too many of them compared to what is socially optimal, and vice versa for low-skill workers.

4. QUANTITATIVE EXPLORATION

In this section, I first estimate the theoretical model using U.S. data. For this exercise, I assume that there is a distribution of heterogenous firms that differ in their technologies. Some of these firms will endogenously be unionized in equilibrium while others will be affected by the threat of unionization. With the estimated model in hand, I conduct several experiments to evaluate the impact of unions on the economy. Finally, I use the calibrated model to shed light on the rapid decline in unionization rates that the U.S. experienced over the last decades.

4.1. *Specification and estimation*

As we have seen in Section 3, the overall curvature of the production function matters for the impact of the threat on the decisions of the firms. To better capture this curvature in the data, I augment the model with capital and assume that firms now operate the technology

$$\tilde{A}_j \left[K_j^{1-\gamma_j} \left(\sum_{s \in \mathcal{S}} z_{j,s} g_s^{\frac{\sigma-1}{\sigma}} \right)^{\frac{\sigma}{\sigma-1}\gamma_j} \right]^{\omega_j}, \tag{26}$$

where $\tilde{A}_j$ is total factor productivity, and γ_j and ω_j are the labour intensity and returns to scale parameters. I also assume that firms can access capital K_j frictionlessly at a constant interest rate $r > 0$.

Supplementary Appendix B shows that once the firm has optimized over its capital input, the new production function (26) takes the same form as the one in the simpler model of Section 2. As a result, this change in production function is innocuous and all the mechanisms explored in the previous sections remain unchanged when capital is included as a factor of production.

4.1.1. Data.

I use data on the private sector of the U.S. economy in 2005. Data on wages and the union status of workers come from the Merged Outgoing Rotation Groups of the Current Population Survey (CPS).[18] I combine these data with the Bureau of Economic Analysis (BEA)

18. I clean the sample by removing agricultural, public sector, and workers who are out of the labour force. I also remove individuals with an hourly wage higher than \$100 or lower than \$5, and individuals younger than 16 or older than 65.

Annual Industry Accounts to calculate the labour share in the union and non-union sectors of the economy, which will be targets in the estimation.[19]

To build a skill index for each worker, I follow Card (1998) and regress log monthly *nonunion* wages on a set of worker characteristics. Denoting by w_i the monthly wage of a worker i who is working in industry j, the regression is

$$\log w_i = \Lambda X_i^1 + \Psi X_{i,j}^2 + \varepsilon_i,$$

where X^1 contains indicator variables that reflect characteristics that are intrinsic to the worker (age, education, occupation, race, and sex) while X^2 contains indicator variables that are related to the job in which the individual currently works (industry and U.S. state). I then construct the skill index $\hat{s}_i$ of worker i as the predicted values associated with the intrinsic variables X^1, so that $\hat{s}_i = \exp\left(\hat{\Lambda} X_i^1\right)$. This way of constructing the index isolates the impact of variables intrinsically related to the individual, and therefore more associated with a notion of skill, from match-related factors that could also influence the wage. Notice that even though the regression is run on nonunion workers only, the predicted values $\hat{s}_i$ are computed for *all* members of the labour force.[20] The support of the distribution is then split into $S = 6$ bins of equal size, which is enough to observe the impact of union policies across skills while keeping the computational complexity at a reasonable level.

4.1.2. Parameters calibrated directly. Several parameters, mostly about preferences and the workings of the labour market, are taken directly from the literature. The remaining parameters—the bargaining powers and technology parameters—are key determinants of the strength of the threat and are estimated directly from the data using a method of simulated moments.

To reflect the typical duration of labour contracts the time period is set to one year. All monetary amounts are measured in thousands of 2005 dollars. The discount rate is set to $\gamma = 0.95$ and the job destruction rate is set to $\delta = 0.113$ to match the job destruction rate in the data (Davis *et al.*, 1998). For the matching function, I use the functional form of den Haan *et al.* (2000) along with the parametrization of Krusell and Rudanko (2016) so that $m(u,v) = uv/(u+v)$. The elasticity of substitution between skills is set to $\sigma = 1.5$ as in Johnson (1997) who summarizes estimates from the literature. For the cost of posting a vacancy, I follow Silva and Toledo (2009) who document that training and vacancy posting costs amount to 69% of quarterly wages. This translates to $\kappa = 1.8$ in the model.[21] The value of these parameters is listed in Table 1. Finally, I use a linear

19. For each industry in the BEA dataset, I compute the labour share by dividing total workers' compensation by value added. I then associate each worker in the CPS sample with the labour share of the industry in which they are currently working. By averaging this variable separately over all union and non-union workers, I find a labour share of 0.597 for union firms and of 0.613 for non-union firms.

20. This approach implicitly assigns to unemployed workers the average occupation and the average industry, in terms of their contribution to skill. An alternative regression that does not include occupation and industry yields a similar skill distribution.

21. Alternative calibrations with a higher job destruction probability of $\delta = 0.4$ and lower vacancy costs, equivalent to 14% of quarterly wages, find a similar impact of labour unions on the economy. The benchmark parameters offer the best fit of the model to the data.

TABLE 1
Parameters calibrated directly

Definition	Parameter	Value	Source/target
Discount factor	γ	0.95	5% annual interest rate
Job destruction probability	δ	0.113	Davis *et al.* (1998)
Skill elasticity of substitution	σ	1.5	Johnson (1997)
Cost of posting a vacancy	κ	1.8	Silva and Toledo (2009)
Number of skills	S	6	See text

function to approximate the CDF ϕ that describes the workers' preference for unionization.[22] The parameters taken directly from the literature are listed in Table 1.

In the model, the value of non-work activities $\boldsymbol{b}$ takes into account unemployment insurance, home production and the value of the extra leisure provided by unemployment. Krueger and Meyer (2002) describe unemployment benefits in major U.S. states and find that the average replacement rate is 54% up to an annual maximum of about \$19,280 in 2005 dollars, when averaged across states. I include these benefits in $\boldsymbol{b}$. To capture the components associated with home production and leisure, I also include a second term in $\boldsymbol{b}$ that scales linearly with the average wage of the worker. I set the slope of this term so that the average value of non-work activities across workers amounts to 85% of the average wage as in Hall (2009).

4.1.3. Technologies. There is a distribution of firms, each using a technology indexed by $j\in[0,1]$.[23] These technologies differ in terms of the curvature α_j of their production functions, their skill intensity vectors $\boldsymbol{z_j}$, and their total factor productivities A_j. As a normalization, I order firms such that a larger j indicates a larger α_j. In addition, I assume that $\alpha_0=0.55$ and $\alpha_1=0.95$ so as to cover a broad range of curvatures.[24] Finally, as Lemma A.1 in the Supplementary appendix shows, we can normalize the mass of each type of firm j to one and let A_j determine the importance of that technology in the economy.

The estimation will determine the technologies used by the firms, but I impose some functional forms to limit the dimensionality of the parameter space to explore. The skill intensities $\{z_j\}_{j\in[0,1]}$ are modelled as probability density functions of truncated log-normal distributions with mean parameters $\{\mu_j\}_{j\in[0,1]}$ and variance parameters $\{\xi_j\}_{j\in[0,1]}$ that vary linearly with j, such that $\mu_j=a^{\mu}+b^{\mu}j$ and $\xi_j=a^{\xi}+b^{\xi}j$. The parameters of these linear relationships are part of the estimation. Similarly, I assume that A_j is a piece-wise linear function of j with one potential break point. That is, there is a $j^*\in[0,1]$ such that $A_j=a_1^A+b_1^Aj$ for $j\in\left[0,j^*\right]$ and $A_j=a_2^A+b_2^Aj$ for $j\in\left(j^*,1\right]$, and $a_1^A+b_1^Aj^*=a_2^A+b_2^Aj^*$. The parameters $\left\{a_1^A,b_1^A,a_2^A,b_2^A,j^*\right\}$ are also part of the estimation. This simple specification has the advantage of having few parameters to estimate and to fit the data well.

22. This linear approximation has several advantages. First, it greatly simplifies the numerical computations. Second, because of the nature of the voting constraint, there is no need to specify the slope of the function, and there is therefore one less parameter to estimate (see Lemma A.2 in the Supplementary appendix). An earlier version of the calibration used micro data from the 1970's about workers' preference for unionization to parametrize a logistic CDF for ϕ. That calibration found a similar impact of unions on the economy but had to rely on older data.

23. The problem of each firm must be solved numerically so that the set of firms must be discretized for the computations. For that purpose, I assume that there are 20 different types of firms—a good compromise between precision and computation time.

24. Since capital is now used as a production factor, α captures the whole curvature of the production function after the firm has optimized on its capital input. See Supplementary Appendix B for details.

TABLE 2
Estimated parameters

Definition	Parameter	Calibrated value
Bargaining powers of workers		
Individual bargaining	β_n	0.46
Collective bargaining	β_u	0.33
Skill intensity vectors $\{z_j\}_{j\in[0,1]}$		
Intercept of the mean	a^{μ}	1.19
Slope of the mean	b^{μ}	0.50
Intercept of the variance	a^{ξ}	0.56
Slope of the variance	b^{ξ}	0.38
Total factor productivities $\{A_j\}_{j\in[0,1]}$		
Intercept of the first segment	a_1^A	36.3
Slope of the first segment	b_1^A	66.6
Intercept of the second segment	a_2^A	−22.0
Slope of the second segment	b_2^A	223.6
Break point	j^*	0.35

4.1.4. Calibrated economy. I use a method of simulated moments to estimate the parameters of the model. In addition to the technology parameters listed above, the estimation also includes the bargaining powers β_u and β_n. The estimation seeks to bring a set of model quantities as close as possible to their data counterparts. The targeted quantities are the union and non-union wage and employment of each skill group, as well as the labour shares in the union and non-union sectors.[25,26]

The parameters are jointly estimated but some intuition can be provided about the moments of the data that matter the most in determining their values. Broadly speaking, the average wage in the union and non-union sectors identifies the bargaining powers β_u and β_n. The parameters that determine the skill intensities $\{z_j\}_{j\in[0,1]}$ are identified from the observed skill distributions in the union and non-union sectors. Finally, the parameters that govern $\{A_j\}_{j\in[0,1]}$ are identified by the overall employment levels and the labour shares in the union and non-union sectors.

Table 2 shows the parameter values that best fit the data.[27] In the calibrated economy, firms with technology indexes between 0 and 0.1 are unionized, while those between 0.1 and 0.55 are affected, to varying degrees, by the union threat. The remaining firms are union free and their decisions are not directly affected by the possibility of unionization.

Importantly, the estimation finds that the union threat distorts the decisions of a sizable mass of firms. The key features of the data that push for that conclusion are the union and non-union wage schedules. Since union wages are relatively high in the data, the estimated value of β_u

25. To compute the labour share, I assume that the returns to scale parameter ω_j is 0.8, in the range estimated by Burnside *et al.* (1995).

26. Adding the outcome of the Freeman (1980) estimator as an additional targeted moment does not affect the results much. Note also that the unemployment rate is implicitly targeted since the total number of workers (employed plus unemployed) is taken directly from the data and that the number of employed workers is a target of the estimation.

27. The estimation finds β_n to be larger than β_u. A few unmodelled features of the data may explain this difference. First, there are costs to unionization: workers may have to pay dues or spend time organizing the union (Voos, 1983). The estimation captures these costs by lowering β_u. Second, consistent with evidence from Farber (1987), union workers might want the firm to hire more workers even if it leads to lower wages. In the model, since an increase in the bargaining power leads to higher wages and to lower employment, this preference would also be captured by a lower β_u. Finally, Bronfenbrenner (1994) and Freeman and Kleiner (1990) detail various tactics, some legal and some illegal, used by firms to prevent unionization. These tactics make it easier for firms to stay union free and they would also be captured by a low β_u.

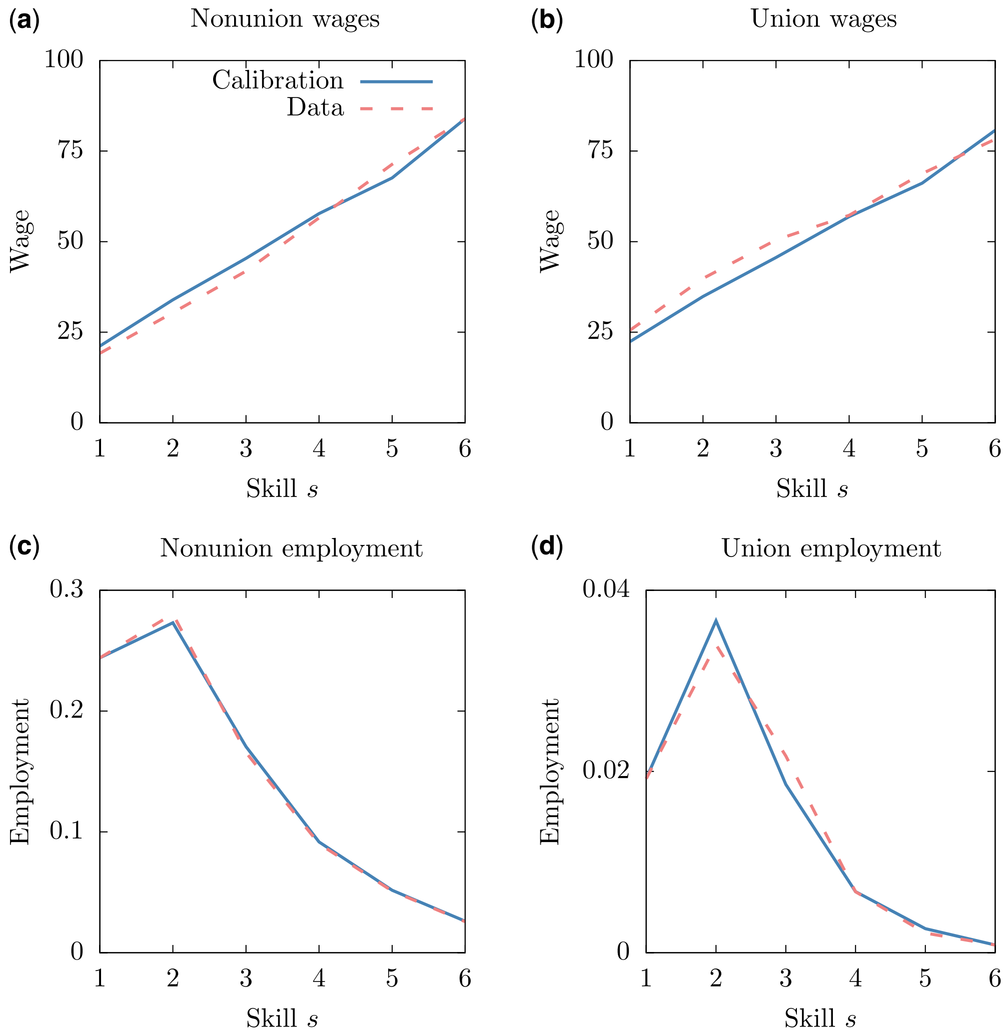

FIGURE 2

Fit of the calibrated model

is high. As a result, non-union workers know that they would have high wages if they were to unionize which pushes them to vote in favour of the union. Non-union firms must then react to prevent unionization.

In the calibrated economy, 9.0% of the population works in a union firm, 24% works in a non-union firm that is subject to the threat of unionization and 67% works in a non-union firm that is not directly affected by the threat. The unemployment rate is 6%. Figure 2 shows how the estimated model fits the wage and employment schedules in the union and non-union sectors.

4.2. *The impact of unions on the economy*

I now evaluate the impact of labour unions on the calibrated economy by considering three experiments in general equilibrium. First, I investigate the role played by the union threat alone ("no threat" experiment). To do so, I assume that workers in non-union firms cannot form a union

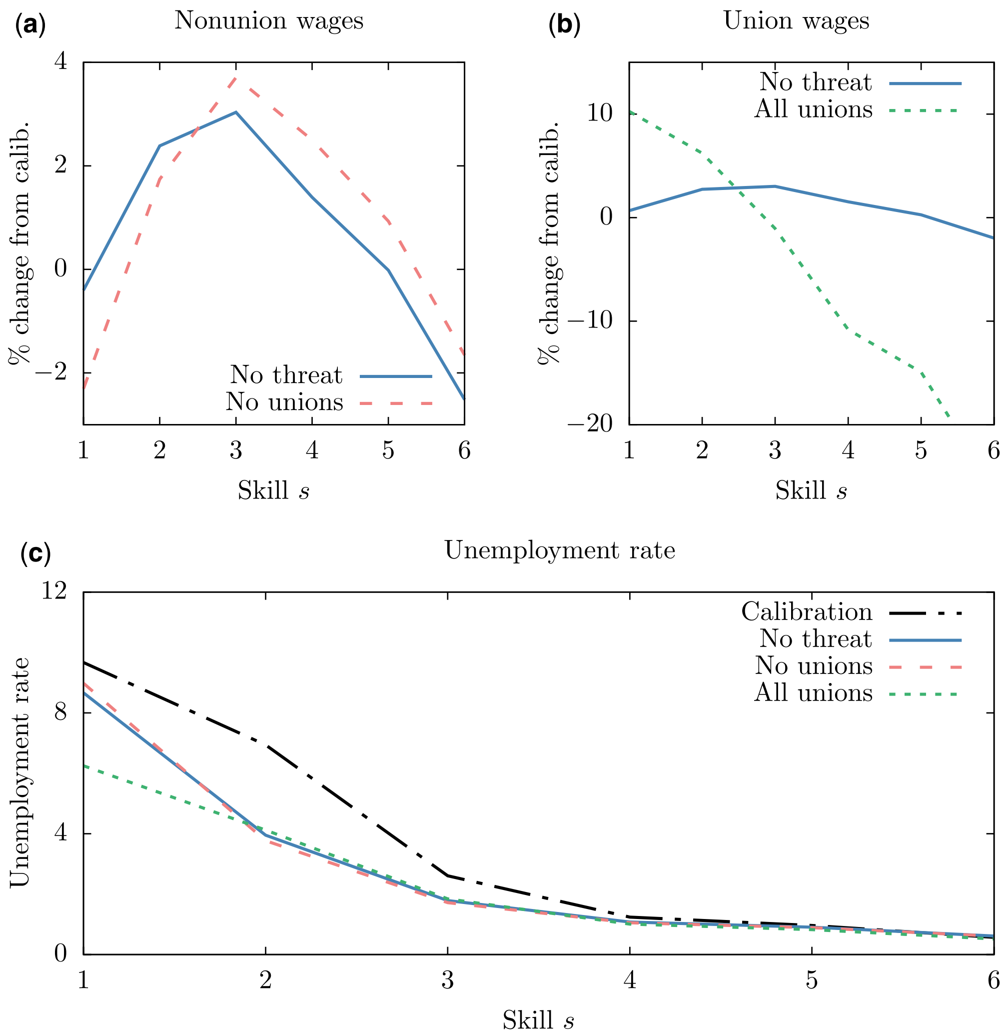

FIGURE 3
General equilibrium impact of experiments

anymore. As a result, these firms no longer distort their behaviour to prevent unionization. In the second experiment, I assume that unions are simply forbidden ("no unions" experiment). In this case, not only does the union threat disappear, but all firms that were previously unionized become union free. This experiment therefore captures the overall impact of labour unions on the economy. Finally, in the third experiment all firms are unionized ("all unions" experiment). Notice that the union threat is inactive in all three experiments.

The results are presented in Figure 3 and Table 3. Figure 3 shows how the experiments influence wages and unemployment rates across the skill distribution. Table 3 shows how aggregate output, unemployment, welfare, and wages react to the experiments. The rest of this section describes how the economic forces at work in the model generate these results.[28]

28. Figures 8 and 9 in Supplementary Appendix C.1 show how union and nonunion employment change in response to the policy exercises. To evaluate the robustness of the experiments, I also include an additional exercise in Supplementary

TABLE 3
Impact of experiments

	Calibration	Changes from calibrated economy		
		No threat	No unions	All unions
Output	44.5	+1.18%	+1.20%	+1.50%
Unemployment rate	6%	−1.48pp	−1.47pp	−2.11pp
Welfare	919	+0.22%	+0.22%	0.28%
Wages				
Mean	3.57	+0.35%	+0.18%	+0.99%
Variance	0.16	+1.19%	+7.73%	−47.4%

Notes: All numbers are percentage changes except for the unemployment rates which are differences in percentage points. Wages are measured in logs. Output refers to value added.

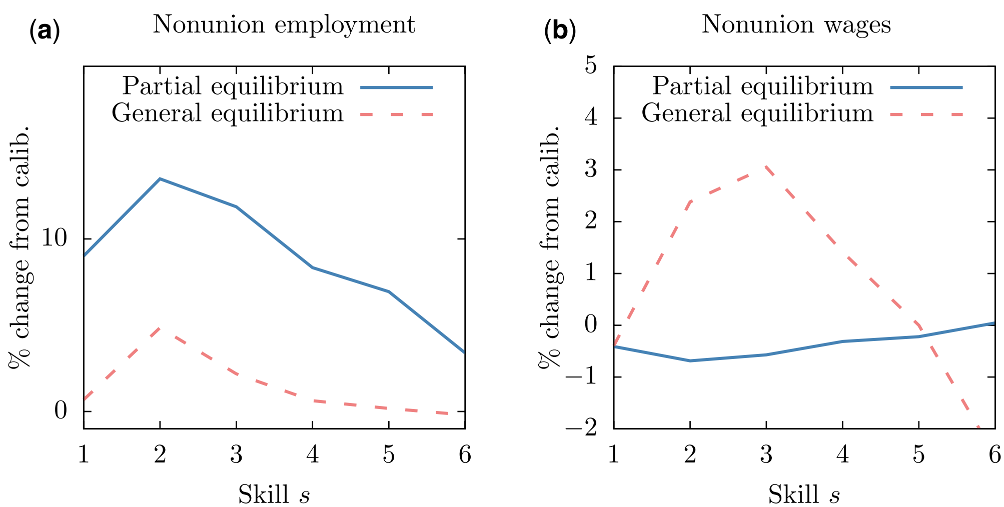

FIGURE 4
Removing the union threat: partial and general equilibrium impact

4.2.1. Impact of the union threat. We begin by considering the first experiment: the removal of the union threat. Figure 4 shows how non-union wages and employment levels react. To better highlight the various mechanisms at work, the solid lines represent the partial equilibrium changes (when all aggregate quantities are kept unchanged) and the dashed lines show the overall impact of the threat removal in general equilibrium.[29]

Let us consider the partial equilibrium reaction of the firms first. From Panel (a), we see that, once the threat is gone, firms hire substantially more, as predicted by Proposition 5. Indeed, when the threat disappears firms are no longer distort their hiring and the marginal cost of production goes down. As a result, firms increase their size to reach the flatter part of their production function. While this increase in hiring affects all workers, the impact is particularly important at

Appendix C.2 in which the mass of firms in the economy adjusts through a free-entry condition. The union threat has a substantial impact on the economy in that environment as well.

29. To be precise, the partial equilibrium exercises keep the labour market tightness $\boldsymbol{\theta}$ and the value of non-work activities $\boldsymbol{b}$ fixed at their calibrated values. Since some firms have curvature α_j close to unity, their employment reacts substantially to the removal of the threat in partial equilibrium, as seen in Panel (a). General equilibrium forces push back these changes in hiring to more modest levels.

the bottom of the skill distribution. When the threat was active, firms were biased against hiring these workers since they voted in favour of unionization. In contrast, high-skill workers were favoured since they voted against the union. The removal of the threat therefore leads to a more modest increase in hiring at the top of the skill distribution than at its bottom.

These changes in employment affect wages in partial equilibrium, as shown by the solid line in Panel (b) of Figure 4. Since firms now hire more, the marginal product of the workers decline which, through individual bargaining, adversely affects wages. Notice that, in partial equilibrium, the disappearance of the threat leads firms to pay a broader range of wages, which pushes for an increase in wage inequality, as predicted by Proposition 6. Indeed, we can see from Figure 4 that high-s wages remain essentially unchanged while low-s wages decline.

In general equilibrium, the increase in hiring pushes unemployment down for all skill groups (bottom of Figure 3) for an overall decline in the unemployment rate of 1.48 percentage points. These lower unemployment levels benefit the bargaining position of the workers, since they can now find other jobs quickly if negotiations break down, which leads to higher wages. In turn, this increase in wages is strong enough to undo the wage decline that was observed in partial equilibrium such that, in general equilibrium, the threat removal leads to higher wages for most workers. Finally, these higher wages tamper the initial increase in employment, so that the increase in hiring generated by the removal of the threat is much smaller in general than in partial equilibrium (panel (a) of Figure 4).

Overall, the removal of the threat benefits non-union workers above the median skill level ($s=2$) more than those below it, as Panel (b) of Figure 4 shows. In general equilibrium, the average wage of workers below the median falls by about 0.4% while that of workers above the median increases by 1.8%.[30] As a result, the removal of the threat increases the variance of log wages by 1.19%. The removal also benefits production, with the increase in hiring that follows the disappearance of the threat pushing output up by 1.18%. Welfare also benefits from the threat removal. Since firms no longer distort their skill mix to avoid unionization, welfare goes up by 0.22%.[31] This increase is smaller than the increase in output since, as many unemployed workers find employment once the threat is gone, the extra value of leisure $\boldsymbol{b}$ that unemployment brought is lost.

Finally, we can consider the impact of the removal of the threat on the distribution of wages across firms. The black line in Figure 5 shows the average wage paid by each firm j in the calibrated economy. The blue line provides the same information but once the threat is gone. We see that the removal of the threat leads to lower wages for workers in previously threatened firms. Once the threat is gone, these firms hire more which decreases the marginal product of the workers and leads to lower wages (see discussion around Proposition 6). The change in wages is also more pronounced for firms facing the strongest threat, around $j=0.1$.

4.2.2. Mandating or prohibiting unions. Figure 3 also shows the impact of the two other experiments: prohibiting all unions or, to the opposite, forcing all firms to be unionized. We see from Panel (a) that removing all unions leads to a substantial increase in wages for workers in the middle of the distribution and to a decline for those in its tails (all workers are non-union workers in this experiment). As very few workers are actually in the right tail of the distribution, this experiment leads to a substantial increase in wage inequality. Since all bargaining is now

30. The bulk of the skill distribution is at skill level $s=3$ and below, as shown in Figure 2. Workers in skill groups 5 and 6 actually suffer from the removal of threat but there are so few workers there that their impact on overall wage inequality is minimal.

31. In contrast, in the social planner's preferred allocation welfare increases by 1.5%.

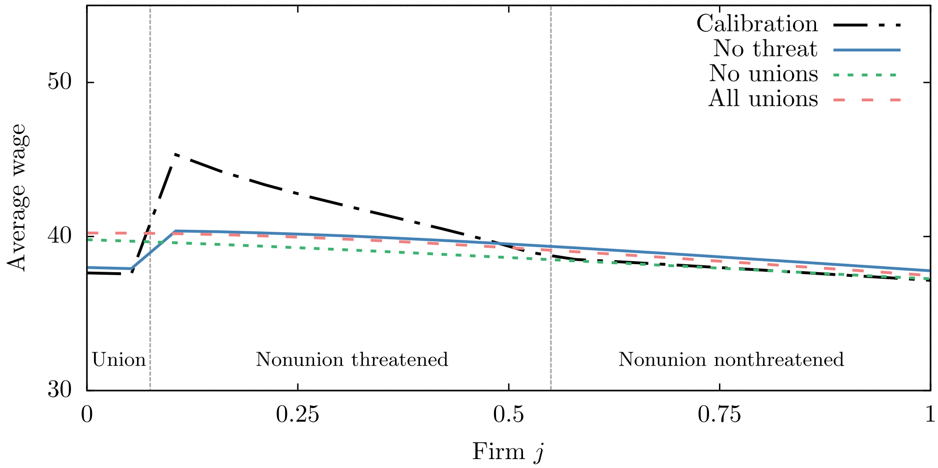

FIGURE 5

Changes in firm-level average wage

done individually, low-skill wages no longer benefit from the high productivity of the high-skill workers. The average worker below the median skill level see her wage fall by 2.3% while the average workers above it gets a wage increase of 2.6%. As a result, the variance of log wages increases by 7.73% from its calibrated value, as shown in Table 3. Output and welfare do not react much more than under the "no threat" experiments.

In contrast, forcing all firms to be unionized leads to a large decline in wage inequality, as can be seen in Panel (b) of Figure 3 (all workers are union workers in this experiment). Since now all wages are bargained collectively, the high-skill workers do not directly benefit from their high productivity and their wages fall substantially. In contrast, workers at the low-end of the skill distribution see massive wage gains from the inclusion of the high-skill workers in the collective bargaining. Overall, the variance of log wages declines by about 48%. Output and welfare are higher under the "All unions" experiment compared to the "No unions" scenario. Unemployment is also at its lowest. Here, the inefficient over-hiring that occurs under individual bargaining is responsible for the differences (see Section 3.3).[32]

Perhaps surprisingly, these experiments show that the threat, on its own, has a larger impact on output and welfare than whether firms are actually unionized or not. To understand why, remember that unionization, by itself, is simply a different way to share the surplus generated by production. Without the threat, firms still seek to maximize that surplus regardless of their union status. As a result, the decisions that matter for the allocation of resources, such as hiring, are relatively unaffected by unionization. In contrast, when the union threat is active, the additional constraint on the firm's problem distracts from surplus maximization, which leads to a decline in output, welfare and employment.[33]

32. Figure 5 shows that since all firms have the same union status, wages are more similar across firms in the last two experiments than in the calibrated economy.

33. To focus on the threat of unionization, the model abstracts from many union-related mechanisms studied in the literature (Freeman and Medoff, 1984). For instance, if union employees could restrict hiring to increase their wage, as in the insider-outsider literature (Lindbeck *et al.*, 1989), the fully unionized economy could feature a higher unemployment rate and a lower welfare level.

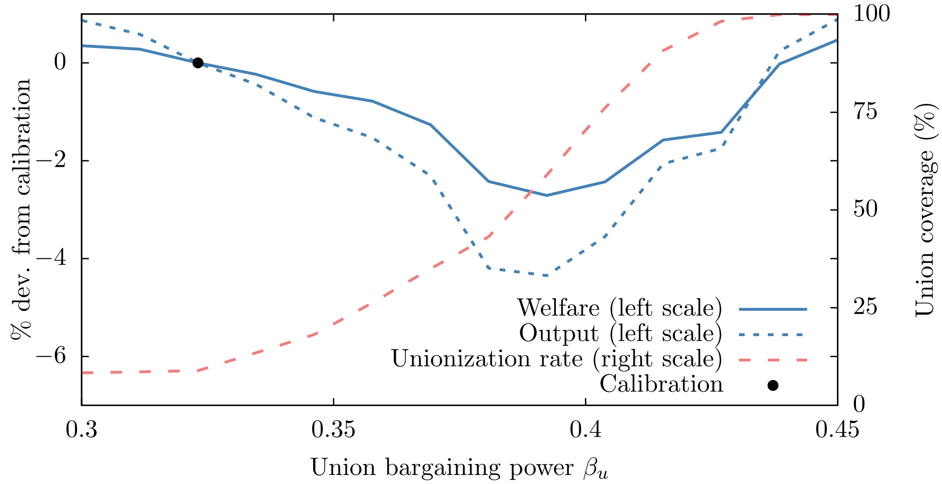

FIGURE 6

Non-monotone relationship between unionization rate and welfare

4.2.3. Policy and the non-monotone relationship between unionization and welfare. The experiments of the last section highlight a non-monotone relationship between the unionization rate and aggregate welfare. Indeed, welfare is higher when the economy is fully unionized, or when there are no unions at all, than under an intermediate situation (the calibrated economy) in which the union threat distorts firms' decisions (see Table 3). Figure 6 emphasizes this point by showing how welfare changes with the union bargaining power β_u. We see that for low values of β_u the economy features a relatively high level of welfare and a low unionization rate, while for high β_u's welfare is still elevated but now the unionization rate is also high. In contrast, for intermediate values of β_u the unionization rate is moderate while welfare in relatively depressed.

Two forces work in opposite directions to create this non-monotonicity. First, keeping the union status of each firm constant, an increase in β_u makes the threat worse for non-union firms. Since these firms' workers now anticipate higher union wages, the firms must distort their skill mix more heavily to prevent unionization, which exacerbates the inefficiencies. Through this first mechanism, an increase in β_u therefore leads to a decline in welfare. There is however a second mechanism that operates through changes in the union status of the firms. As β_u increases, there comes a point at which it is so costly to prevent unionization that a firm prefers to let its workers unionize. In this case, there is no longer any reason to distort hiring, which is beneficial for welfare. These two forces compete to generate Figure 6. Increasing β_u, starting from the calibrated economy (black dot), initially leads to a decline in welfare. For a small increase in β_u, not many firms change their union status but the threat becomes more important and threatened firms distort hiring more heavily. As β_u keeps increasing, there comes a point at which welfare begins to increase. At these high levels of union bargain powers, firms simply decide to let the workers unionize and the threat no longer distorts their decisions. This point is reached around $\beta_u \approx 0.39$ in Figure 6. Further increases in β_u after this point lead to large changes in the unionization rate as firms unionize massively.

The mechanisms at work in Figure 6 have important consequences for policy design. In particular, any policy that slightly strengthens the bargaining position of unions from its calibrated value—for instance the repeal of a right-to-work law—is welfare decreasing as it increases the distortion created by the threat. In contrast, increasing β_u by a large amount, say to 0.45, would

TABLE 4
Comparing the 1983 and the 2005 economies

	1983	2005
Output	41.4	44.5
Welfare	885	919
Unemployment rate	10.9%	5.8%
Unionization rate	19.7%	9.0%
Workers in threatened firms	52%	24%
Workers in low labour share firms	31.0%	26.5%

Notes: Firms under threat are those for which the voting constraint is binding. Low labour share firms are those with technologies $0<j<0.5$.

be welfare improving as the threat would then affect fewer firms. In practice, the optimal design of a policy should weigh the negative impact of increasing the threat (stronger distortion for remaining nonunion firms) against its positive impact (fewer firms are subject to it).

4.2.4. The decline of unions in the U.S. Over the last few decades the unionization rate has declined significantly in the U.S., from 19.7% in 1983 to 9.0% in 2005.[34] Over the same period, heavily unionized sectors such as manufacturing, transportation and utilities have been slowly declining as well, suggesting that a change in industrial composition was one driver behind the decline in unionization.[35] In this subsection, I modify the calibrated model to replicate the industrial composition of the U.S. in 1983 and then use the model to evaluate how the impact of unions on the economy has changed over the last decades.

In the data, the heavily unionized sectors of the economy feature lower labour shares, so that they correspond to technologies with lower indexes j in the calibration. To match the 1983 economy, I therefore adjust the mass of firms using each technology $j\in[0,1]$ to match the union and non-union employment vectors.[36] Once this is done, I then compute the general equilibrium in this new economy.

Table 4 presents key moments of the 1983 and 2005 economies side by side to highlight their differences. We see that the change in industrial composition leads to a lower output, higher unemployment and a higher unionization rate in 1983. In addition, employment in industries with low labour shares was higher, and a much larger fraction of workers where in firms whose decisions were constrained by the threat of unionization.[37]

We can decompose the changes in Table 4 as the sum of a change in the impact of the union threat and a residual that captures the direct effect of the change in industrial composition on the economy. I measure the impact of the union threat by implementing the "no union threat" policy experiment described in Section 4.2 in both economies and by taking the differences between outcomes. The results are presented in Table 5. We see that the union threat is responsible for a good fraction of the overall changes experienced by the U.S. economy between 1983 and 2005. For instance, the decline in the intensity of the threat was responsible for an increase of 2.6% in

34. 1983 is the earliest year in the sample with consistent CPS data.

35. Acemoglu *et al.* (2001), Açikgöz and Kaymak (2014), and Dinlersoz and Greenwood (2016) investigate the link between technological changes and labour unions. Dinlersoz *et al.* (2017) document which firms are targeted by unions.

36. As Lemma A.1 in the Supplementary Appendix shows, this is equivalent to adjusting the TFPs $\{A_j\}_{j\in[0,1]}$. I therefore pick the slopes b_1^A and b_2^A to match the union and non-union employment vectors.

37. The set of firms constrained by the threat is $[0.1,0.7]$ is 1983 and $[0.1,0.55]$ in 2005.

TABLE 5
The union threat between 1983 and 2005

	Changes from 1983 to 2005 accounted for by		
	Direct impact of new industrial composition	Union threat	Total
Output	+4.8%	+2.6%	+7.4%
Unemployment rate	−2.7pp	−2.4pp	−5.1pp
Welfare	+3.1%	+0.8%	+3.9%

Notes: Differences from the calibrated economy. All numbers refer to percentage changes except for the unemployment rate number which show the difference in percentage point. Output is measured as value added.

output and 0.8% in welfare. Unsurprisingly, the change in industrial composition itself was a key driver of the changes over that period.[38]

5. REDUCED-FORM ESTIMATES

The empirical literature on unions frequently relies on reduced-form estimators to make predictions about the impact of unions on wages. In this section, I discuss how these estimators do not take into account the threat of unionization and how this can lead to incorrect predictions. I also provide reduced-form estimates of the impact of the union threat on wages by taking advantage of changes in legislation in certain U.S. states. This last exercise provides model-free supporting evidence for the quantitative analysis of the previous section.

5.1. *Comparison with common reduced-form estimators*

5.1.1. Estimating the impact of unions on wage inequality. In the calibrated economy, the true impact of unions on wage inequality differs from what common reduced-form estimators suggest. To show this, I first consider the well-known estimator introduced by Freeman (1980). That estimator seeks to compute the variance of wages in a counterfactual economy with no unions. It proceed by assigning to each union worker a counterfactual nonunion wage drawn from the observed non-union wage distribution. This estimator can be written as

$$V-V^n=U\Delta_v+U(1-U)\Delta_w^2,$$

where V is the observed variance of log wages, V^n is the variance of log wages without unions in the economy, U is the unionization rate, Δ_v is the difference in the variance of log union and non-union wages, and Δ_w is the difference between the mean log of union and non-union wages. When used on the calibrated economy, that estimator suggests that unions are responsible for lowering the variance of log wages by 3.63%. In contrast, in the "no union" experiment above unions are responsible for lowering wage inequality by 7.73%, more than twice as much.

More sophisticated estimators also take into account the fact that union and non-union workers differ in terms of observable characteristics such as education, age, etc. (see for instance Dinardo and Lemieux (1997), Card (2001), and Card *et al.* (2004)). The idea is to attribute to every union worker a draw from the non-union wage distribution of workers with the same observable characteristics. Taking this heterogeneity into account, these estimators predict that

38. Table 5 isolates the impact of the union threat but the numbers barely change if we isolate the total impact of unionization (threat plus change in bargaining protocol) instead.

unions are responsible for lowering the variance of log wages by 0.72%, or only about 9% of their true impact on wage inequality.[39,40]

The key reason why these reduced-form estimators do not capture the full impact of unions is that they assume that the union and non-union wage schedules themselves are unaffected by the disappearance of labour unions from the economy. In the model, however, these schedules react to the disappearance of unions for multiple reasons. First, in the calibrated economy the union threat distorts the wages that non-union firms pay. When unionization is no longer an option, the threat disappears and the non-union wage schedule becomes steeper as a result. Second, union and non-union firms in the model use different technologies. Indeed, their union status differ precisely because they use different technologies. Therefore, when previously unionized firms become union free they pay wages that differ from those paid by the previously union-free firms. This results in a change in the non-union wage schedule, which is now coming from a richer mix of technologies. Finally, the reduced-form estimators abstract completely from general equilibrium mechanisms. In particular, when unions disappear firms tend to hire more which, through the increase in the outside option of workers in the labour market, pushes all wages upward. As this channel affects workers with different skills differently, it leads to asymmetrical changes in the wage schedules. Putting all these mechanisms together explains the differences between the reduced-form and model-based estimates of the impact of unions on wage inequality.

5.1.2. Regression discontinuity estimators. The model can also shed light on why regression discontinuity estimators tend to find a small impact of unionization on firm-level outcomes. For instance, DiNardo and Lee (2004) compare firms that barely win a union election to firms that barely lose an election and find essentially no significant impact of unionization. They mention that a union threat effect would tend to bias the estimates against finding a strong impact of unionization. The idea is that if non-union firms pre-emptively change their behaviour to prevent unionization, the control group—the firms that barely win the election—is also affected by union policies and the estimator therefore misses the full impact of unions.

We can use the model to evaluate the magnitude of the bias introduced by the threat. To do so, I consider, in the calibrated economy, a threatened non-union firm that faces a bargaining power β_n such that, if it were to unionize, its total employment would not change, as in DiNardo and Lee (2004).[41] I then compare the impact of unionization on this firm under two different scenarios. In the first scenario, the firm is initially threatened by unionization, as in the calibrated economy. In the second scenario, the firm is initially unaffected by the threat. The differences between these two scenarios is indicative of the impact of union policies that is not captured by the regression discontinuity estimator. Table 6 shows the results of the exercise. We see that for employment, output and the wage bill, the threatened firm reacts less to unionization than its non-threatened

39. The Freeman estimator predicts a larger impact of unions on wages inequality than the estimators that control for heterogeneity since the union skill distribution is more concentrated than the non-union skill distribution (see Figure 2). Since the estimator assumes that a union worker would get a random draw from the non-union wage distribution if she or he were not unionized, this leads to an overestimation of the true impact of unions on wage inequality.

40. These estimators can also be thought of as non-targeted moments for the estimation. In the raw data, the Freeman estimator finds that unions lower the variance of log wages by 2.6% while the corresponding number for the estimator that takes into account worker heterogeneity is 1.2%. The equivalent numbers in the calibrated economy are 3.63% and 0.72%, respectively. Both estimators therefore take similar values in the data and in the calibrated economy.

41. Since the firm does the minimum needed to avoid unionization, the outcome of a union election would be close to 50% and, assuming that some random shock pushes the workers to barely vote in favour of unionization, a regression discontinuity estimator would find no impact of unionization on employment. I assume that the firm has the technology $j=0.1$, the non-union firms closest to unionization.

TABLE 6
Impact of unionization on threatened and non-threatened firm

	Initially threatened?		Difference
	Yes	No	
Employment (%)	+0.0	−7.2	7.2
Output (%)	−5.2	−8.8	3.6
Wage bill (%)	−1.8	−8.6	7.8

counterpart. These results suggest that the full impact of union policies can be larger than implied by regression discontinuity estimators.

5.2. *Right-to-work laws and the threat of unionization*

In this subsection, I provide supporting evidence for the quantitative exercise of Section 4. To do so, I use the passage of right-to-work legislations by U.S. states as a source of variation in union power and rely on reduced-form methods to measure the impact of the threat on the earnings of non-union workers.

Several states in the U.S. have passed right-to-work (RTW) legislations since World War II. These laws prohibit contracts between labour unions and employers that mandate that workers pay union membership fees as a condition of employment. As a result, under these laws unions have access to fewer resources, which limits their ability to organize and leads to a weaker threat of unionization. By estimating the impact of these laws on non-union earnings, we can therefore evaluate the impact of the union threat.[42]

The data come from the Merged Outgoing Rotation Groups of the Current Population Survey. The sample covers the period from January 1989 to December 2018 and includes the passage of right-to-work laws in Indiana (2012), Kentucky (2017), Michigan (2012), Oklahoma (2001), Texas (1993), West Virginia (2016), and Wisconsin (2015).[43]

Table 7 shows the outcome of ordinary least-square regressions of log weekly earnings on a right-to-work law indicator variable that equals one if the individual resides in a state with a right-to-work law and zero otherwise.[44] We see from Column 1 that the passage of a RTW law is associated with a significant decline in the earnings of all workers. Breaking down workers by their union status, Column 2 shows that the earnings of *non-union* workers decline by about 3% after the passage of a RTW law. This decline is consistent with a weaker threat of unionization after the passage of right-to-work laws. Since non-union firms are less worried about unionization, they no longer have to keep wages high to influence a union vote. The same mechanism operates in the model (see Proposition 6). These results are also consistent with the partial equilibrium reaction of the firms in the calibrated economy, as shown in Figure 4. Finally, the third column of

42. This exercise complements the previous literature, discussed in the introduction, in two ways. First, since several RTW laws have been passed in recent years, an up-to-date exercise provides a more current estimate of the impact of the union threat. Second, I consider the impact of the laws on union and non-union earnings separately, something that few studies do and that allows me to explicitly evaluate the impact of the threat on non-union firms. One exception is Farber (2005), who studies the impact of RTW laws in Idaho and Oklahoma.

43. These data come from IPUMS (Flood *et al.*, 2015). January 1989 is the first month with consistent weekly earnings data. Missouri passed a RWT in 2017 but the law was repealed before it could take effect. I restrict the sample to the adult civilian population and I remove government/military employees, part-time workers, and individuals in management occupations.

44. The standard errors are clustered at the state level. The significance levels are the same with two-way clustering at the state-time level instead. With robust standard errors, all coefficients are significant at the 1% level.

TABLE 7
Impact of right-to-work laws on weekly earnings

	(1)	(2)	(3)
Dependent variable	Earnings	Earnings	Earnings
Workers in the sample	All	Non-union	Union
Right-to-work law	−0.038**	−0.029**	−0.035
	(0.019)	(0.013)	(0.033)
State and time fixed effects	Yes	Yes	Yes
Individual and state controls	Yes	Yes	Yes

Notes: Ordinary least-square regressions. The dependent variable is the log of weekly earnings for all workers (1), non-union workers (2), and union workers (3). Standard errors, clustered at the state level, are in parenthesis. Individual controls are industry, occupation, age, sex, and education. The state control is the unemployment rate. The data covers the adult civilian population in the Current Population Survey Merged Outgoing Rotation Groups between January 1989 and December 2018. I remove from the sample government/military employees, part-time workers and individuals in management occupations. Union workers include union members and workers covered by a union. Significance levels: * $p<0.1$, ** $p<0.05$, *** $p<0.01$.

Table 7 suggests that, unsurprisingly, RTW laws have a negative impact on the earnings of union workers, although the estimate is not statistically significant.[45]

6. CONCLUSION

This article proposes a general equilibrium theory of endogenous union formation to study the impact of unions on the economy. Unions are created by a majority vote within each firm. If a union is created, wages are bargained collectively otherwise each worker bargains his or her wage individually with the firm. This asymmetry in wage setting mechanisms causes unions to compress the wage distribution inside a firm and to lower its profit. A key mechanism in the theory is that, to prevent their own unionization, non-union firms distort their hiring decisions in a way that also compresses the range of wages and reduces employment and output. The main predictions of the theory are in line with stylized facts about unions. Experiments using an estimated version of the model show that removing the threat of unionization increases the variance of wages while also raising output and welfare and lowering unemployment. The model therefore provides guidance about the outcome of policy interventions that would aim to weaken unions, such as the passage of right-to-work legislations by state legislatures, or make them stronger.

This article also emphasizes the importance of off-equilibrium paths for on-equilibrium quantities. When economic agents try to avoid utility/profits-reducing situations, they can take actions that affect observed aggregates, even though the unwanted situation is never actually observed. In that spirit, firms threatening to outsource production abroad might lead to lower wages even though no outsourcing actually takes place. A similar mechanism could also operate for firms that threaten to automate to save on labour costs.

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45. One worry about these regressions is that the passage of right-to-work legislations might not be exogenous. In particular, lawmakers might pass these laws in bad economic times in an attempt to sustain the economy. To control for the business cycle, I therefore include the state-level unemployment rate in the regressions. The results are also robust to including as regressors the state-level minimum wage and unemployment benefits extensions, as shown in Supplementary Appendix D.1. Similar regressions for the skill premium and the skill mix hired by firms are reported in Supplementary Appendix D.2.

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Supplementary Data

Supplementary data are available at *Review of Economic Studies* online.

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