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The rising skill premium and deunionization

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ABSTRACT

During the past 50 years, the US economy has seen a rapid decline in labor union membership and a substantial rise in wage inequality. Since labor unions compress wages between skilled and unskilled workers, a rising skill premium encourages skilled workers to withdraw from the union. If this withdrawal is accompanied by a fall in the productivity of unskilled workers, firms become reluctant to hire the relatively expensive union workers, reinforcing the decline in the unionization rate. Evaluating this hypothesis, we find that the rise in the skill premium explains about 40% of the decline in the unionization rate.

1. Introduction

The US economy witnessed significant changes in the earnings distribution throughout the twentieth century. The Gini coefficient of earnings inequality was 0.48 in 2004, up from a century low of 0.32 in the late 1950s (Fig. 1). This was closely mirrored by the rate of unionization, which rose sharply after the Great Depression, peaking at around 28% in the 1950s and decreasing ever since. These trends are not unique to the US. Australia, the Netherlands, and the UK experienced similar hikes in wage inequality accompanied by declines in the unionization rate between 1980 and 1992. Meanwhile, the wage inequality was declining in Italy and Belgium as labor unions were gaining strength (Wallerstein, 1999; Wallerstein and Western, 2000).

The negative correlation between wage inequality and unionization is commonly interpreted as the outcome of efforts by labor unions to achieve a more equal distribution of wages among their members. Egalitarian union practices, such as limitations on performance-based pay or negotiation of across-the-board wage raises for all workers, result in a compressed wage structure in union establishments (Hirsch, 1982; Freeman, 1980; Freeman and Medoff, 1984; Card, 1996).

The abundance of evidence provided by studies on wage compression has led to claims that the decline of the unions was a major factor in explaining the rise in wage inequality in the US (Freeman, 1993; DiNardo et al., 1996; Card, 1998; Fortin and Lemieux, 1997; Koeniger et al., 2007). These studies consider deunionization to be an exogenous process. Nevertheless, when the prevalence of unions is considered as an outcome of the economic incentives of firms and workers, one could also argue that a third factor caused the observed trends, given the egalitarian practices by labor unions.

In a labor market with free mobility, the extent of unionization depends crucially on the productivity distribution, workers' choices among union and non-union jobs, and firms' hiring decisions. If unions establish transfers among their members to achieve equality, then workers weigh the rents extracted by negotiating collectively against the transfer

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Fig. 1. Deunionization and wage inequality in the US. *Note*: Unionization is measured as a fraction of all employed workers. Wage inequality is measured by the Gini coefficient. Sources: Kopczuk et al. (2010) and Mayer (2004).

payments among unionized workers. These payments may discourage skilled workers from joining the union, while encouraging the unskilled workers to do so. On the other hand, if unionized firms have discretion over whom to hire in response to wages set by the union, they would do so selectively, admitting only those who are productive enough to make up for the high union wage. In such an economy, a change in the productivity differences among workers, due, for instance, to technical change, alters the checks and balances within the unionized establishments, leading to a change in the wage distribution as well as the unionization rate. This is the direction of causality examined in this paper.

A rise in the skill premium in the non-union sector could both raise the wage inequality and reduce the rate of unionization. Consider a technical change that increases the productivity of skilled workers while deflating the value of skills possessed by low-productivity workers.[1] The higher skill premium raises the opportunity cost of being a union member for skilled workers and encourages them to get jobs in the non-union sector, where they are better rewarded for their skills. Meanwhile, as the productivity of the unskilled workers declines, firms become reluctant to hire them at the relatively high union wage. The combination of two events generates a large decline in the rate of unionization, and appears to be a reasonable description of the US deunionization experience.

Although the endogeneity of labor market institutions has been acknowledged as a potential concern in the aforementioned studies, the literature has failed to address this concern satisfactorily. This paper thus aims to contribute to this literature by exploiting the structure of a model to assess the role of endogenous union participation in response to changes in the distribution of productivity. To this end, we develop a macroeconomic model of unionization, which is consistent with the observed relationship between skills, union participation, and wage distribution in 1978.[2] When the model parameters are changed to reflect the observed rise in skill prices since 1978, the unionization rate declines from 32.1% to 22.9% in 2007. Considering that unionization was, in fact, 10.2% in 2007, the model explains approximately 40% of the observed deunionization in the data.

Was there an amplification effect due to deunionization? In particular, how much wage inequality would have increased had there been no technical change but complete deunionization for exogenous reasons? We find that once the non-random selection into unions is accounted for, unions have little effect on the equilibrium wage distribution, in contrast to the findings of previous studies (Freeman, 1993; DiNardo et al., 1996; Fortin and Lemieux, 1997). The selection of the workers from the middle of the skill distribution, in particular, leads to overestimation of the effect of unions on wage dispersion. Studies that attempted to control for selection, such as Card (2001) and Lemieux (1998), are closer to our findings.

Our paper is closest to Acemoglu et al. (2001), who consider the incentives of skilled workers to leave the union in response to a skill-biased technical change. The model presented here is compatible with this argument, and the empirical findings lend support to their conjecture. Nevertheless, this paper can be distinguished in two ways. First, we find that the weakening of firms' incentives to hire low-skilled union workers is equally important for understanding the US deunionization experience. Second, the approach here is primarily quantitative while that of Acemoglu et al. (2001) is solely theoretical.

[1] Although technical change is used as an example, an alternative explanation of lower productivity, for instance, one based on the emergence of international competition for low-skill jobs, would be equivalent.

[2] The approach in this paper requires micro-level data on union coverage in the US, which became available in 1978.

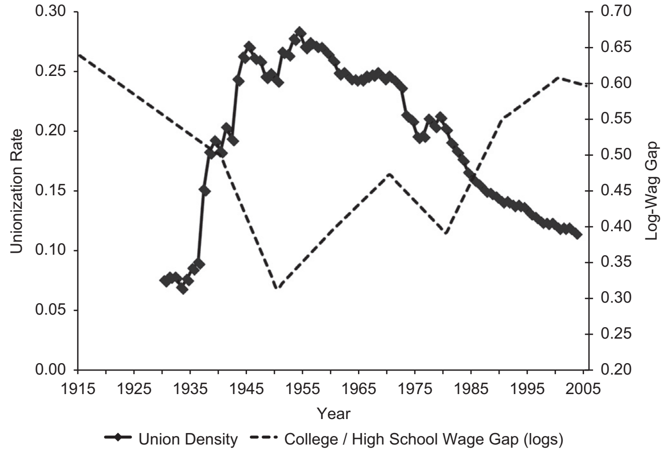

Fig. 2. Union membership and college wage premium in US. Sources: Goldin and Katz (2008) and Mayer (2004).

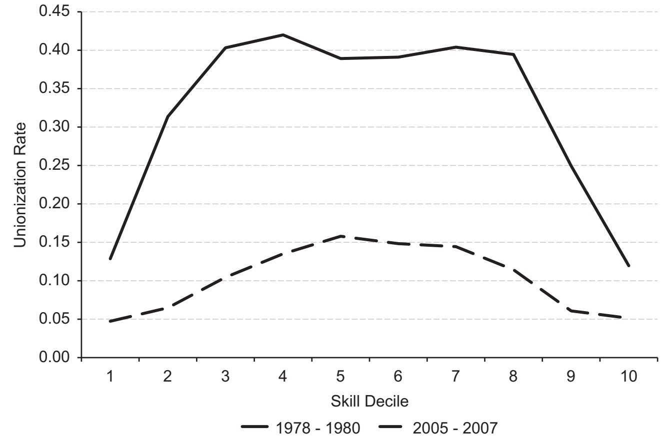

Fig. 3. Union coverage density by predicted skill deciles. *Note*: The sample consists of male, private wage, and salary workers over the age of 16 from the CPS May supplements (1973–1981) and the monthly MORG files (1983–2007). Observations are stratified into deciles based on predicted wages in the non-union sector. See Section 4.1 for details.

2. The deunionization experience in the United States

To put things in perspective, let us begin by discussing the long-term trends in the unionization rate, wage inequality, and skill premium. Fig. 1 suggests that the rise in the wage inequality began around 1960. The fall in the unionization rate had begun shortly before, but the decline remained limited to 3 percentage points until the late 1960s. Following the rise in the wage inequality, the unionization rate decreased by an additional 13 percentage points. The college wage premium started to increase in 1950, preceding both the fall in the unionization rate and the rise in wage inequality (Fig. 2). This suggests that the rise in skill premium could have instigated the trends in unionization and wage inequality.[3]

To illustrate the role of skill in union status, Fig. 3 displays the union participation rate by measured skill.[4] The union participation rate has an inverse-U shape, consistent with the interpretation that the skilled workers prefer the non-union sector for better pay, while union jobs are "hard to get" for low-skill workers (Farber, 1983; Abowd and Farber, 1982; Card, 1996). The selection of the workers from the middle of the skill distribution affects how the overall unionization rate responds to the rise in the skill premium. For instance, if the withdrawal of the skilled workers from the union is matched by the inclusion of less skilled workers, the unionization rate would stay constant in response to technical change. The unionization rates in Fig. 3 decline for all skill groups between 1978 and 2007. Furthermore, the hump-shaped profile of union participation by skill flattens over time. A coherent theory of deunionization must be consistent with these facts.

[3] The college wage premium falls in the 1970s owing to an increase in the supply of college workers (Welch, 1979; Katz and Murphy, 1992; Goldin and Katz, 2008; Kaymak, 2009). Since college workers have, in general, lower unionization rates, this leads to a contemporaneous decline in unionization. This apparent irregularity is, in fact, consistent with the model described in this paper.

[4] Skill is defined by the predicted wages in the non-union sector, based on the returns to education and experience. See Section 4 for details.

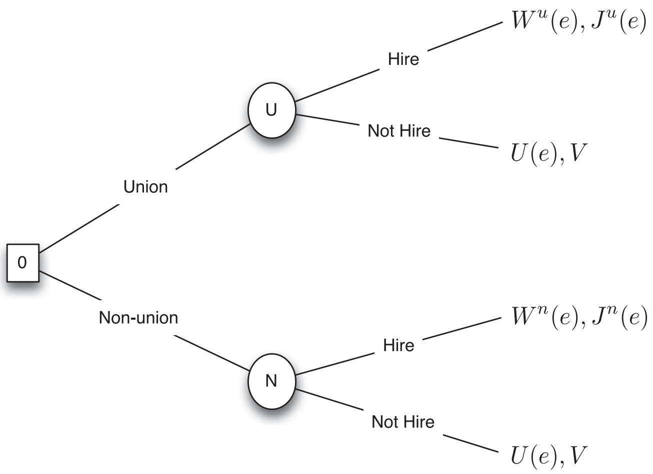

Fig. 4. Game tree and payoffs for the union game. *Note*: Figure shows the timing, strategies and payoffs for the union game between a firm and a worker of efficiency e.

3. A model of union participation

A version of the Mortensen–Pissarides (MP) search model (Mortensen and Pissarides, 1994; Pissarides, 2000) is employed for the analysis.[5] The search and matching frictions lead to rents that are divided between the employer and the worker, allowing for collective bargaining as an alternative to bilateral bargaining between the firm and individual workers.

The explicit matching process also allows for strategic incentives at the worker-firm level to model the selection into unions. Union membership is endogenous in our model. The union is an outcome of the interaction of firms' and workers' incentives, and it is the composition of the workers in the union that determines union wages. The model is rich enough to provide strong predictions on which workers end up being selected into union jobs. Equilibrium union models in the literature are silent in this dimension where this selection is often overlooked (Grossman, 1983; Ebell and Haefke, 2006).

3.1. Baseline model

To see the qualitative features of our full model more transparently, consider first a simple model. This baseline model is later augmented with additional features for the quantitative analysis.

3.1.1. Environment

There is a continuum of risk-neutral workers with a unit measure and a large measure $N \gg 1$ of risk-neutral and ex ante identical firms. Time is discrete and all agents have a common subjective discount factor $\delta \in (0,1)$. Each worker is endowed with productive skill/labor efficiency $e \in \mathbb{R}$ with distribution $\mu(.)$. Worker efficiency is common knowledge for all agents in the economy. There is a representative sector and a representative union.

When a vacant position is filled, the firm-worker pair produces $f(e)$. The function $f: \mathbb{R} \to \mathbb{R}_{++}$ is continuously differentiable, measurable with respect to μ, $f'(e) > 0$, $\lim_{e \to -\infty} f(e) = 0$, and $\lim_{e \to \infty} f(e) = \infty$.

3.1.2. Matching, strategic union choice, and recursive formulation

Every period, vacant positions and unemployed workers are randomly matched. Given the measure of vacant positions, v, and the unemployed, u, the measure of matched pairs is represented by the constant-returns-to-scale (CRS) matching technology $m(v,u)$.

Define $\theta \equiv v/u$ as the labor market tightness. The CRS assumption implies the following formulations of the relevant matching variables: $p(\theta) \equiv m(v,u)/u = m(\theta, 1)$, and $q(\theta) \equiv m(v,u)/u = m(1, \theta^{-1}) = p(\theta)/\theta$.

Under a law of large numbers, $p(\theta)$ denotes the probability of an unemployed worker being matched with a firm and $q(\theta)$ is the probability of a vacant position being matched with a worker.

When a firm is matched to a worker, the firm observes the worker's efficiency $e \in \mathbb{R}$ and both parties observe union wage w^u. Then they play a non-cooperative game in which the worker moves first, deciding whether or not to join the union, and the firm decides whether or not to hire the worker, conditional on the worker's decision. We call this game the "union game". Fig. 4 represents the game tree, decision nodes, and payoffs. Let $M^w(e)$ and $M^f(e)$ denote the equilibrium payoffs for the worker and the firm respectively.

[5] Some of our results are available in a separate Supplementary Document.

Here, $W^u(e)$ and $W^n(e)$ represent the employment value for a union worker and a non-union worker of efficiency e, respectively. $J^u(e)$ and $J^n(e)$ are similarly defined for the firm. In case the firm does not hire the worker, the worker gets the unemployment value $U(e)$ and the firm stays vacant and gets value V.

3.1.3. Workers' value functions

Value of a non-union job to a worker is given by

$$W^n(e) = w^n(e) + \delta[\lambda U(e) + (1-\lambda)W^n(e)]. \tag{1}$$

A non-union worker receives the non-union wage $w^n(e)$. The match breaks next period with an exogenous probability of $\lambda \in (0,1)$ in which case the worker gets $U(e)$. With probability $(1-\lambda)$, the match is retained.[6]

Similarly, the value of a union job that pays a wage rate w^u for a worker is

$$W^u(e) = w^u + \delta[\lambda U(e) + (1-\lambda)W^u(e)]. \tag{2}$$

The value of unemployment for a worker with efficiency e is represented by

$$U(e) = b(e) + \delta[p(\theta)M^w(e) + (1-p(\theta))U(e)],$$

where $b(e)$ represents the unemployment benefits received by the worker.[7] With probability $p(\theta)$, the worker is matched with a firm and gets $M^w(e)$. The worker remains unemployed if he is not matched with a firm (with probability $1-p(\theta)$). It will be clear later that, at the equilibrium, all matches end up in employment.

3.1.4. Firms' value functions

The firm's benefit from a filled position depends on the union status of the worker. The values are

$$J^n(e) = f(e) - w^n(e) + \delta[\lambda V + (1-\lambda)J^n(e)] \tag{3}$$

$$J^u(e) = f(e) - w^u + \delta[\lambda V + (1-\lambda)J^u(e)] \tag{4}$$

for a non-union worker and a union worker, respectively. From the firm's perspective, the only difference between the two positions is the wage rate paid to the worker. The value of a vacancy is given by

$$V = -\kappa + \delta\left(q(\theta)\int M^f(e)\,d\mu + (1-q(\theta))V\right), \tag{5}$$

where $\kappa > 0$ is the cost of entry for a firm. A vacancy is matched to a worker at the rate $q(\theta)$ every period. With probability $(1-q(\theta))$, the position stays vacant.

3.1.5. Wage determination

All wages are determined by bargaining over the match surplus. If a non-union worker is hired, the wage is determined by Nash bargaining, with worker bargaining power $\beta \in (0,1)$:

$$w^n(e) \in \arg\max \beta \log[W^n(e) - U(e)] + (1-\beta)\log[J^n(e) - V]. \tag{6}$$

Unionized workers bargain collectively with their employers. The “firm leader” and the “union leader” bargain over the total surplus generated by union jobs. The union has a higher bargaining power $\gamma \in (0,1)$ in wage negotiations than an individual worker.

Let $\mathcal{U} \subset \mathbb{R}$ denote the set of values for $e \in \mathbb{R}$ for which the worker would choose to be a union member. The union wage w^u solves the following problem:

$$\max_{w^u} \gamma \log\left(\int_{\mathcal{U}} [W^u(e) - U(e)]\,d\mu\right) + (1-\gamma)\log\left(\int_{\mathcal{U}} [J^u(e) - V]\,d\mu\right). \tag{7}$$

3.1.6. Equilibrium

The model is closed by a free-entry condition $V \le 0$, which pins down $\overline{N}$, the measure of firms operating at the steady state.

The unemployment benefit $b(e)$ is determined at the equilibrium as a constant share $0 < \rho < 1$ of equilibrium wage, $b(e) = \rho w(e)$, where ρ represents the income replacement ratio.[8] With this assumption, all matches end up in employment, and wages have a very simple structure, to be clarified in the next section.

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[6] One could also express the next period value assuming that the union game is repeated every period. At the steady state, the outcome would be identical to that of the simpler specification.

[7] For analytical convenience, we depart from the literature by allowing the benefits to be worker-specific. In our model, unemployment benefits will be tied to wages and therefore are determined as part of the equilibrium. Furthermore, the financing of unemployment benefits is not modeled for simplicity. Accordingly, potential feedbacks from the government budget constraint are absent here.

[8] Since efficiency e is fixed for each worker, at the steady state, every worker of efficiency e has the same union status and the same wage. Unemployment benefit is a constant fraction of the wage earned if the worker *were to be* employed. Therefore $b(e)$ is uniquely defined for each worker.

The equilibrium in this economy is defined as follows:

Definition 1. A *steady-state equilibrium with unions* consists of the wages $w^u \in \mathbb{R}_+$, $w^n : \mathbb{R} \to \mathbb{R}_+$; unemployment benefits $b : \mathbb{R} \to \mathbb{R}_+$; value functions M^f, M^w, J^u, J^n, W^u, W^n, $U : \mathbb{R} \to \mathbb{R}$, $V \in \mathbb{R}$; and labor market tightness $\theta \in \mathbb{R}_+$, such that, given w^u, w^n and b,

1. $M^f(e)$ and $M^w(e)$ constitute the equilibrium payoffs of the union game for each $e \in \mathbb{R}$.

Given the set of union workers,

2. Non-union wages: $w^n(e)$ is determined by individual bargaining (6) for each $e \in \mathbb{R}$.
3. Union wages: w^u is determined by collective bargaining (7).
4. Optimal vacancy posting: $V \geq 0$.
5. Free entry: $V \leq 0$.
6. Labor market tightness: $\theta = v/u$ where u satisfies $u = \lambda/(p(\theta)+\lambda)$ and v satisfies $v = \lambda \overline{N}/(q(\theta)+\lambda)$.

Consistency

7. Wages w^u, w^n and the equilibrium strategies for the union game are consistent with each other.
8. Unemployment benefit satisfies $b(e) = \rho w(e)$.

3.2. Analysis of the baseline model

Characterization of the equilibrium begins with the non-union wages.

3.2.1. Non-union wages

For what is to follow, we define a strictly increasing function $C : [0,1] \to [0,1]$ as follows:

$$C(z) = \frac{z[1-\delta(1-\lambda)] + z\delta p(\theta)}{[1-\rho(1-z)][1-\delta(1-\lambda)] + z\delta p(\theta)}. \tag{8}$$

Using the equilibrium conditions $V=0$, $b(e) = \rho w^n(e)$, along with Eqs. (1), (3) and (6), the non-union wage function can be expressed as

$$w^n(e) = C(\beta) f(e), \tag{9}$$

where $C(\beta)$ is the fraction of the production retained by the worker in wages. This implies, from Eq. (5), that the value to a filled non-union position is simply $J^n(e) = [1-C(\beta)]f(e) > V = 0$.

At the equilibrium, a filled non-union position is always preferable to keeping the position vacant for another period. This is a direct consequence of the zero-profit condition for posted vacancies at the equilibrium and of the assumption that the flow value of unemployment is proportional to the worker's wage. It is straightforward to show, in a similar manner, that the optimality of a non-union match is mutual, i.e., $W^n(e) > U(e)$ holds for all values of e; therefore, all non-union matches result in employment.

3.2.2. Union membership

The following proposition characterizes the workers who are represented in the union.

Proposition 1. *Given the union wage $w^u > 0$, there exist $\overline{e}$ and $\underline{e}$ such that a worker is a union member if and only if $\underline{e} \leq e \leq \overline{e}$.*

Proof. Given that $J^n(e) > V$ and $W^n(e) > U(e)$ for each $e \in \mathbb{R}$, the equilibrium payoffs of the union game can be expressed in a compact way as

$$(M^w(e), M^f(e)) = \begin{cases} (W^u(e), J^u(e)) & \text{if } W^u(e) \geq W^n(e) \text{ and } J^u(e) \geq V \\ (W^n(e), J^n(e)) & \text{if } W^u(e) < W^n(e) \text{ or } J^u(e) < V. \end{cases}$$

The equilibrium above introduces two threshold values of efficiency, $J^u(\underline{e}) = V = 0$ and $W^u(\overline{e}) = W^n(\overline{e})$. Eq. (4) implies that $J^u(\underline{e}) = 0$ if and only if $f(\underline{e}) = w^u$. Provided that $w^u > 0$, a unique threshold is guaranteed to exist since $f'(e) > 0$, $\lim_{e \to -\infty} f(e) = 0$, and $\lim_{e \to \infty} f(e) = \infty$.

Similarly, Eqs. (1), (3), and (9) imply that $W^u(\overline{e}) = W^n(\overline{e})$ if and only if $w^u = w^n(\overline{e})$. Since $w^{n'}(e) > 0$, $\lim_{e \to -\infty} w^n(e) = 0$, and $\lim_{e \to \infty} w^n(e) = \infty$, this threshold is uniquely defined.

Now observe that $f(\underline{e}) = w^u = w^n(\overline{e}) \leq f(\overline{e})$ where the last inequality follows from (9). Since $f'(e) > 0$, we have $\overline{e} \geq \underline{e}$. It is easy to check that the inequalities for union membership are satisfied for all $\underline{e} \leq e \leq \overline{e}$. □

Non-union wage $w^n(e)$ is increasing in e; therefore, workers with higher productivity choose not to be a part of the union, since their skill is better rewarded in the non-union sector. On the other hand, low-efficiency workers, should they choose to join the union, are not desired by the firm. Since the worker is better off employed than not, the worker strategically chooses to bargain individually. The equilibrium of this game is such that union workers are selected from the middle of the productivity distribution, which formalizes the observation by Farber (1983): Both firm and worker incentives play a role in determining the union status of a worker.[9] Effectively, firms determine the lower bound, and workers determine the upper bound on the productivity of union workers.

The strategic interaction adopted here seems unusual, since the firm may refuse to hire a worker if the worker chooses to join the union. This assumption is reasonable for two reasons: First, the firm never exercises this option at the equilibrium, since it never gets to play at this decision node with a low-efficiency worker. Second, at the steady-state equilibrium, a worker optimally looks for either a union job or a non-union job.[10] In this sense, the equilibrium outcome mimics the dynamics of a directed search model, though such elements are not made explicit.

3.2.3. Union wages

At the equilibrium, union wage is determined by the efficiency composition of union workers. The following expression, which solves the union bargaining problem (7), characterizes the union wage[11]:

$$w^u = C(\gamma)\mathbb{E}[f(e)|e \in [\underline{e}, \overline{e}]]. \tag{10}$$

This equation has a very simple interpretation when it is compared to Eq. (9): The union wage is a constant share of the average productivity of the union workers. Since $C(\gamma) > C(\beta)$ when $\gamma > \beta$, union workers, on average, keep a larger portion of their product than if they were to bargain individually.

Equilibrium is reached when union participation can be rationalized by the union wages, as calculated above. Eqs. (10), $f(\underline{e}) = w^u$, and $w^n(\overline{e}) = w^u$ can be solved simultaneously to find the equilibrium values of union wage w^u, upper bound $\overline{e}$, and lower bound $\underline{e}$.

3.3. Rising skill premium and deunionization

Consider now a rise in the price of skill which raises the productivity of high-efficiency labor that is accompanied by a fall in the productivity of the low-efficiency labor. Fig. 5 depicts an example where the production function takes the form $f(e;\psi) = \exp(\psi e)$ and $e \sim N(0,1)$. Here ψ denotes the price of skill. A rise in ψ is represented by a rotation of $\log f(e;\psi)$. Since wages in the non-union sector are proportional to productivity, the wage curve for this sector also rotates. The union workers with the highest productivity choose to opt out of the union, since the cost of wage transfers within the union increases relative to gains from collective bargaining. This results in an inward shift of $\overline{e}$. Similarly, the union workers with the lowest productivity cannot stay in the union since their productivity fails to compensate for the high union wage. Consequently, $\underline{e}$ increases. Both of these changes reduce the size of the union as depicted in panel (b) of Fig. 5.[12]

3.4. Extended model

Our model is now extended to capture the aspects of the data that are pertinent for the quantitative results. In particular, the data shows incomplete wage compression in union establishments. Wages in unionized firms vary with observable measures of skill, such as seniority and education, albeit the premiums are lower relative to the non-union sector. Furthermore, conditional on observable measures of skill, wage dispersion has been very limited at the plant level (Freeman and Medoff, 1984).

For these features to be captured in the model, assume that individual output is given by $f(s,x) = \exp[\psi(s+x)]$, where s is an observable and verifiable measure of skill, such as educational attainment, available to everyone, including the union. The residual measure of skill, referred to here as ability x, on the other hand, is observed only by the worker and the employer. The variables s and x are assumed to be independently and normally distributed with means μ_s and μ_x, and variances σ_s^2 and σ_x^2.[13]

[9] The timing of the game is crucial for the equilibrium selection. A similar game, where the firm plays first and the worker responds, leads to an inefficient equilibrium. A worker with low enough efficiency would be unemployed because he would prefer the union wage to the non-union wage, but these workers are not productive enough to make up for the high union wage.

[10] One can make an alternative interpretation: If a worker has low efficiency that worker would not apply for a union job since the firm would hire the best workers in the queue of applicants for the position. A high enough waiting cost would induce the worker to apply for a non-union job in the first place.

[11] Imposing the condition $b(e) = \rho w^u$ as a final step yields this expression.

[12] A change in the composition of union workers generally triggers a small change in the equilibrium union wage. For clarity, parameters of the numerical example depicted in Fig. 5 were chosen such that the equilibrium union wage remains the same after the price of skill rises. The parameters used in the numerical example are $\beta=0.057$, $\gamma=0.117$, $\delta=0.99^{1/3}$, $\rho=0.40$ and $p(\theta)=0.324$. The skill price increases from $\psi=1$ (solid lines) to $\psi=2$ (dashed lines).

[13] This setup is akin to a statistical discrimination model, where unions cannot observe or verify productivity y directly and therefore rely on s to infer it statistically. In that context, $x = \log y - \log E[y|s]$ represents the prediction error (in logs). The independence assumption employed here is therefore innocuous, because any potential correlation between s and x would be captured by the union's prediction and thereby reflected in the wage.

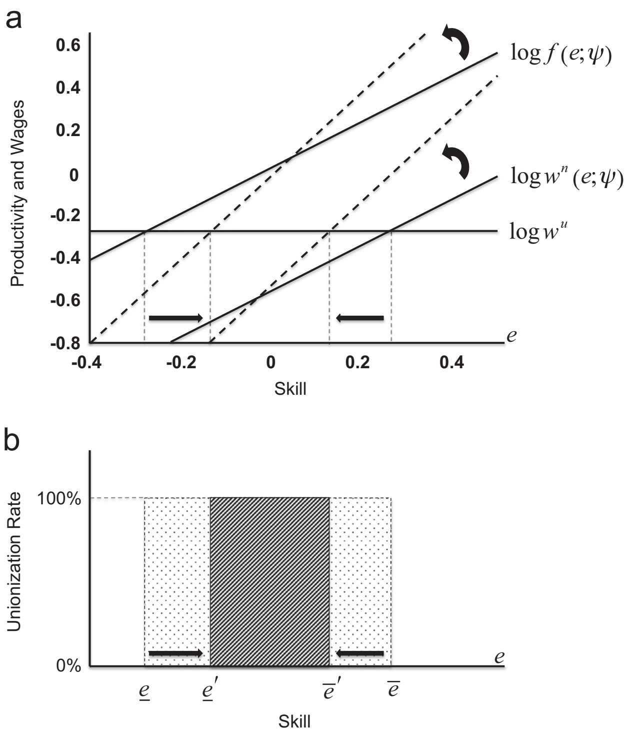

Fig. 5. (a) Rising skill premium and (b) the unionization rate. *Note*: Unions are comprised of workers with medium productivity (between $\overline{e}$ and $\underline{e}$). A rise in the skill premium in the non-union sector (rotation of $\log f(e)$ and $\log w^n(e)$) pushes the critical values inward, leading to deunionization.

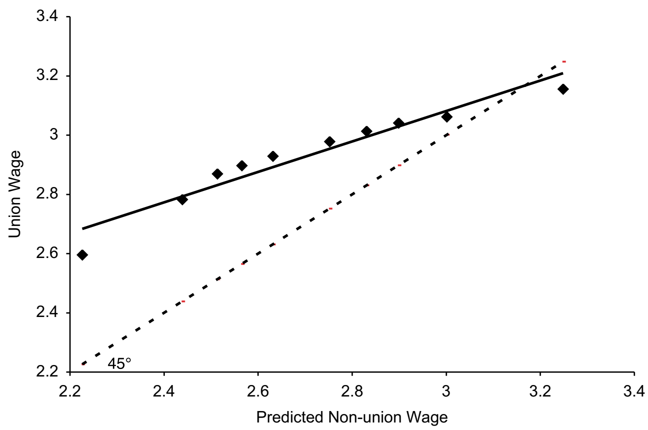

Fig. 6. Union wage policy. *Note*: Figure plots wages of union workers on the hypothetical wage that they would have earned in the non-union sector. Predicted non-union wage is estimated based on the education levels and experience of union workers, as well as the returns to these variables in the non-union sector.

In the extended model, the log-wage function in the non-union sector is $\log w^n(s,x) = \log C(\beta) + \psi(s+x)$. The union bargains over the productivity of the average union worker, as predicted by his measurable skill. The implied union wage function depends only on s. This is consistent with the lack of pay-for-performance contracts in union establishments (Lemieux et al., 2009). The union wage function is assumed to be $\log w^u(s) = \log \phi_0 + \phi_1 \psi s$, where $\phi_1 \in (0,1)$ denotes the relative price of skill in the union sector. In this model, the assumption of how union wages vary with skill has no theoretical foundations; rather, it is empirically motivated since a log-linear form fits the empirical union wage function well, as depicted in Fig. 6. In this setup, the degree of wage compression depends negatively on the relative price of skill in the union sector: $1-\phi_1$.[14] Parameter ϕ_0 is determined endogenously by Nash bargaining (see problem (7)).

[14] More precisely, this term is the skill price compression. Total wage compression, as defined by one minus the ratio of log-wage variances, is $1-\phi_1^2\sigma_s^2/(\sigma_s^2+\sigma_x^2) > 1-\phi_1$. This, however, is not the equilibrium wage compression, since the variances are not conditional on union status.

The following proposition is analogous to Proposition 1 and characterizes the selection of unionized workers in our general model. The proof is similar to that of Proposition 1 and is included in a separate appendix.[15]

Proposition 2. *Given the union wage policy* (ϕ_0, ϕ_1), *a worker is a union member if and only if* $\log \phi_0 \le \psi(1-\phi_1)s + \psi x \le \log \phi_0 - \log C(\beta)$.

As $\phi_1 < 1$, union workers are selected from the middle of the skill distribution given x. This captures the two-sided selection discussed in the previous section. Furthermore, x and s are substitutes: A union worker with high observed skills is likely to have low unobservable skills. This result is consistent with Hirsch and Schumacher (1998), who find, using National Longitudinal Survey of Youth (NLSY) data, that union workers with high measured skills have relatively low unobservable skills, as approximated by Armed Forces Qualification Test (AFQT) scores.

4. Empirical analysis and the calibration of the model

The model economy is calibrated to reproduce the labor market conditions in 1978 and then used to predict the unionization rate in 2007, based on the estimated changes in the skill prices in 2007. The parameters related to search and matching frictions can be calibrated based on the values in the literature. We estimate the skill prices in the union and non-union sectors, as well as the distribution of skills in the labor force, and use them as calibration targets for the remaining parameters.

4.1. Estimation of the skill prices

The productivity distribution and skill prices are identified in two steps. First, the skill prices are estimated assuming that union status is random. Some of these estimates are biased when union status is endogenous. Second, the selection, implied by the model, helps identify the underlying true parameters. If one were to estimate the skill prices with simulated data, ignoring selection, the estimates would coincide with those obtained in the data. This is essentially an indirect inference approach. Let $j \in \{n, u\}$ denote the non-union and union sectors, respectively. Marginal product of worker i at time t is given by

$$\log y_{it} = X_{1it}\Gamma_{jt} + X_{2it}\Psi_{jt} + \varepsilon_{ijt}, \tag{11}$$

where X_1 is a vector of skill characteristics and X_2 is a vector of non-skill-related controls. Note that skill prices vary across non-union and union sectors. Under random selection into union jobs, $E[\varepsilon_{iut}|X_{1it}, X_{2it}] - E[\varepsilon_{int}|X_{1it}, X_{2it}] = 0$, i.e., conditional on observable skills, the union and non-union workers are comparable. This allows for a consistent estimation of skill prices Γ_{jt} using standard methods.

We begin by constructing a skill composite for workers, corresponding to s in the model, based on the observed prices in the non-union sector. Worker i's skill priced at time t is obtained by estimating (11) for non-union workers and calculating the prediction $\hat{s}_{it} = X_{1it}\hat{\Gamma}_{nt}$ for *all* workers. The standard deviation of $\hat{s}_{it}$ gives an estimate of $\psi_t \sigma_{st}$. The skill price in 1978, ψ_{1978}, can be normalized to 1 without loss of generality. This allows the identification of $\sigma_{s,1978}$ by the dispersion in $\hat{s}_{it}$. The standard deviation of $\hat{s}_{it}$ in 2007 relative to 1978 corresponds to $\psi_{2007}\sigma_{s,2007}/\sigma_{s,1978}$ in the model. We assume that $\sigma_{s,2007} = \sigma_{s,1978}$, which gives an estimate of the skill price in the non-union sector in 2007, ψ_{2007}. We verify below that when the distribution of skills is allowed to change as observed in the data, keeping the skill prices fixed in their 1978 levels, the implied skill dispersion remains stable.

The degree of skill price compression is estimated by projecting the actual wages of union workers on their predicted skills and non-skill-related controls:

$$\log w_{itu} = \zeta_t \hat{s}_{it} + X_{2it}\Psi_{ut} + \varepsilon_{itu}. \tag{12}$$

The coefficient of $\hat{s}_{it}$ measures the relative price of skill in the union sector, and hence, the skill price compression corresponding to $1-\phi_{1t}$ in the model.

When union status is non-random, ε_{ijt} in Eq. (11) is correlated with union status. Among workers with low (high) values of observed skill, only those with high (low) unobserved ability join the union. As a result, skill premium is overestimated in the non-union sector and underestimated in the union sector when selection is ignored. Consequently, direct estimations of Eqs. (11) and (12) lead to exaggeration of wage compression by the union and to overestimation of the dispersion of skills, σ_s. These estimates are corrected for selection using the model.

4.2. Introducing selection using the model of union participation

Three of the parameters cannot be estimated directly: the dispersion of ability, σ_x, the bargaining powers of the union, γ, and of the individual workers, β. The model's predictions for union participation by skill are used to identify these parameters and to correct the selection bias in the reduced-form estimates. We assume throughout that these parameters remain constant at their 1978 levels.

[15] See online Supplementary Material.

Table 1
Calibrated and estimated parameter values.

Parameters	Value	Target moments	
Exogenously calibrated parameters			
Discount rate (δ)	$0.99^{1/3}$	Annual interest rate	4%
Unemployment benefit (ρ)	0.400	Shimer (2005)	
Skill premium – 1978 (ψ_{1978})	1.000	Normalization	
Matching exponent (α)	0.500		
1978 Economy (jointly calibrated)			
Matching coefficient (η)	0.324	Avg. unemp. duration	3.09 months
Separation rate (λ)	0.020	Unemployment rate	6.03
Vacancy cost (κ)	1.392	$\theta=1$	
Union bargaining power (γ)	0.387	1978 union profile	See Fig. 3
Competitive bargaining power (β)	0.240	1978 union profile	See Fig. 3
Skill dispersion (σ_s)	0.261	Estimated skill dispersion	0.284 (0.001)
Ability dispersion (σ_x)	0.108	1978 union profile	See Fig. 3
Relative union skill price (ϕ_1)	0.605	Estimated union skill price	0.536 (0.018)
2007 Economy			
Skill premium (ψ_{2007})	1.326	Estimated skill dispersion	0.285 (0.005)

Note: Numbers in parentheses are the standard errors that are used to weigh the moments. See text for details.

Given the estimate of the dispersion of skill, σ_s, dispersion of ability σ_x determines the curvature of the unionization profile. For low values of σ_x, union participation by skill approaches a step function, as in our baseline model. For large values of σ_x, the union profile becomes flat. Therefore, the curvature identifies a unique value of σ_x.

The literature provides little guidance on choosing the bargaining powers of unions and individual workers relative to their employers. For the benchmark economy in 1978, we therefore simultaneously choose the collective and the individual bargaining powers (γ and β), the relative skill price in the union sector (ϕ_1), and the standard deviations of the distributions of skill (σ_s and σ_x), to match the observed rate of unionization by deciles of the predicted skill distribution ($\hat{s}_i$), the reduced-form estimates of the standard deviation of the skill distribution ($\hat{\sigma}_s$), and the estimated wage compression within the union ($\hat{\zeta}$). There are a total of 12 moments and 5 parameters. Because the moments outnumber the parameters, each data moment is weighted by the inverse of its standard deviation.

4.3. Calibration of the search environment

The time period for the analysis is 1 month. The corresponding monthly discount rate is $\delta=0.99^{1/3}$. The vacancy cost, κ, is chosen to normalize the equilibrium labor market tightness θ to unity. The CRS matching technology takes the form $m(v,u)=\eta u^{1-\alpha}v^{\alpha}$. When $\theta=1$, the probability of being matched with an employer is η. The average duration of unemployment in 1978, which is 3.09 months, implies a value of 0.32 for η. Given the job-finding rate, the separation rate is set to $\lambda=0.02$, to match the average unemployment rate of 6.03%, for years 1978–1980. We set $\alpha=0.5$ and $\rho=0.4$ (as reported by Shimer (2005) to be a reasonable estimate of the income replacement ratio).[16] The means of skill and ability, μ_s and μ_x, are set to 0. This implies that when the skill price, ψ, rises, non-union wages decrease for half of the workers, comparable to the 57% observed in the data. The first panel in Table 1 summarizes the calibrated parameters.

4.4. Data and estimation results

The analysis requires micro-level data on wages and union coverage, which becomes available starting in 1978 for the US. The analysis is therefore limited to the 1978–2007 period. The data used for the estimations is a combination of the May Supplements to the Current Population Surveys for years 1978–1980 and the Merged Outgoing Rotation Group files for the years 2004–2007. The sample is restricted to male, private wage, and salary workers over the age of 16.[17] The union coverage in this sample declined from 32% in 1978 to 10% in 2007.

Skill is measured by educational attainment and potential experience. Education is categorized into five levels: less than high school, high school, some college (less than 16 but more than 12 years of education), college, and more than college.

[16] The standard Hosios efficiency condition does not hold, but a *version* of the Hosios condition holds in this economy that maps the bargaining powers β and γ to the elasticity parameter α. This result is due to two groups having different bargaining powers. A change in the parameter α has almost no effect on our results.

The implications of the search and matching model for the business cycle appear to be sensitive to the choice of ρ (Hagedorn and Manovskii, 2008). This is not the case for our model since we are concerned with long-run trends in unionization. Our results are robust to different values for ρ.

[17] A mildly declining pattern can also be observed among female workers, while unionization has increased in the public sector. See Farber (2005) for trends in unionization in the public sector and Katz and Krueger (1991) for a discussion of the impact of rising skill premium on the public sector.

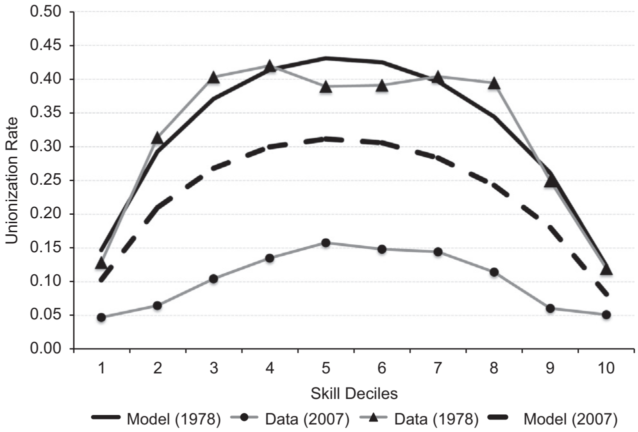

Fig. 7. Model deunionization by skill deciles: 1978–2007. *Note*: Figure compares the predictions of the model for the unionization rate to the data for each decile of observed skill (education and experience).

A full set of interaction indicators between each year of potential experience and each education category in X_1 is included when estimating (11). Indicators for race, marital status, and survey year are included in X_2 as controls.[18]

The standard deviation of the estimated skill index is 0.28. A regression of actual wages on the skill composite for union workers yields 46% wage compression ($\hat{\phi}_1 = 0.54$) in 1978. These auxiliary estimates, along with the union participation by deciles of predicted skill composite in 1978, as shown in Fig. 3, are used to estimate the underlying parameters that are corrected for selection.

The second panel in Table 1 summarizes the parameters and the corresponding moments.[19] The corrected estimate of skill dispersion is 0.26, slightly lower than the reduced-form estimate, as expected. The actual wage compression by the union in 1978 is 39%, implying a 7% selection bias.

Fig. 7 compares the skill distribution of unionization in the model with the data. The model closely replicates the observed hump-shaped pattern in the data. The ability of the model to match the entire profile with a few parameters confirms our assumptions regarding the selection process and the distributions of skills.

The implied bargaining powers for individual workers and the union are 0.24 and 0.39 respectively. The estimate of the standard deviation of ability, σ_x, in 1978 is 0.11. Combined with the estimate of σ_s, the variance of log-wages implied by the model is 0.08. This indicates that the heterogeneity in worker-specific productivity constitutes a quarter of the total wage variance.

4.5. *Union wage premium*

The cross-sectional predictions of our model are evaluated by examining the union wage premium implied by the model. The estimates of the union premium by quintiles of the skill distribution are 0.40, 0.34, 0.26, 0.16, and -0.04, for an average of 0.20. The model successfully captures the declining union premium pattern by skill. The model's predictions are 0.27, 0.14, 0.05, -0.04, and -0.16. The negative premiums indicate the presence of selection with respect to unobserved skill. The average union wage premium in the model is 0.05, well below the estimate in the data. This could happen for a few different reasons. First, the data may contain additional heterogeneity, for instance, at the firm level, leading to an even stronger selection of workers than the model predicts.[20] A second reason could be that the search and matching frictions, as calibrated to unemployment rates, are not strong enough to generate a large surplus. The Appendix A (Supplementary Material) contains an analysis of the sensitivity of the results to alternative parameter values that improve the fit of the model to the observed wage gaps.

5. The composition effect of unionization on wage inequality

Before analyzing the implications of the rising skill premium in the model, we use the estimated wage functions to gauge the effect of unions on wage inequality by asking the following question: What would the overall wage inequality be if all union workers were paid according to the non-union wage structure in the 1978 economy? Since the log-wage function in

[18] Since years 1978, 1979, and 1980 have been combined, two survey-year indicators for 1979 and 1980 are included here.

[19] Although we report calibrated parameters next to the reduced form estimates in Table 1, it is understood that, strictly speaking, all parameters determine all endogenous variables jointly.

[20] There is some evidence to this effect in recent studies using matched employer–employee data. Guertzgen (2006) finds the selection-corrected union wage premium to be 0–2.3% in West Germany and Breda (2010) finds it to be 2.5% in France. These are comparable to the figures in DiNardo and Lee (2004) for the US, obtained with a different methodology.

the non-union sector is $\log C(\beta)+\psi(s+x)$, the hypothetical variance without unions is $\psi^2(\sigma_s^2+\sigma_x^2)=0.08$. Given that the actual variance of log-wages in the model is 0.079 in 1978, the effect of unions on the variance of wages is −0.0006, which is less than 1% of the total model variance. This implies that the wage compression within the union sector is almost offset by the wage gap created between the union and the non-union sector. The composition effect of deunionization constitutes 1–2% of the total rise in wage inequality in the model. These figures support the conclusion that the contribution of deunionization to the rise in wage inequality has been limited.

The difference between the estimates here and in earlier studies (DiNardo et al., 1996; Freeman, 1993; among others) is primarily due to the non-random selection into the union sector. Since union workers are selected from the middle of the skill distribution, ignoring selectivity leads to overestimation of the wage dispersion in the non-union sector and underestimation of dispersion in the union sector. When selection is ignored, as in Freeman (1993), for instance, the estimate of the composition effect is −0.03, or 50 times the true effect! Correcting for selection by observed skills, as in Card (2001), reduces the effect only to −0.006, which is still 10 times the true effect. Therefore, ignoring selection by unobserved ability has significant implications for how much unions are thought to reduce wage inequality.[21] Next to be addressed is the change in the skill premium as the driving force behind rising wage inequality and deunionization.

6. Technical change, deunionization, and wage inequality

The implications of the rising skill premium for the unionization rate can be analyzed by raising the price of skill in the model. This requires a measure of skill prices in the non-union sector in 2007 relative to 1978. The increase in the price of skill is calibrated to match the increase in the standard deviation of the skill composite estimated for 2007, $\hat{s}_{i,2007}$, while all remaining parameters are fixed. The estimate of the standard deviation of predicted skill component is 0.346 when corrected for selection, which implies that the price of skill increased by 32.6% between 1978 and 2007 (1.326=0.346/0.261).

One might be worried that the increase in the standard deviation of predicted wages is coming from the rise in the distribution of skills in the population, and not from the change in the price of skill. This does not appear to be the case. Evaluating the distribution of observed skills in 2007 using skill prices estimated for 1978 yields a standard deviation of 0.285, virtually the same as the 0.284 estimated in 1978. Therefore, changes in skill prices, and not the composition of education or experience, appear to be responsible for the rise in wage inequality.

The unionization rate predicted by the model in response to the rise in the skill premium is 22.9%. This is about 40% of the total drop in the unionization rate from 1978 to 2007. Fig. 7 compares the union participation rates by skill, before and after the rise in the skill premium. The unionization rates fall for most skill groups, particularly for the middle group. This results in a union participation profile that is slightly flatter, as in the data. Keeping all else constant, the nature of the change in the skill premium pushes both the lowest and the highest productivity workers out of the unions. Since the unionization rate is already low at the tails of the skill distribution, most of the decline comes from the workers in the middle.

The model emphasized two critical decision margins in play during the deunionization process: the decline in the demand for unions by the skilled workers, and the decline in the supply of union jobs for the unskilled workers. The two channels can be decomposed by evaluating the unionization rate in 2007 under the assumption that the skilled workers' unionization decision remained at its 1978 level. The rate of unionization in this case drops to 27.8%, which is approximately half of the total decline predicted by the model. Firms' resistance to hiring union workers is therefore equally important in explaining the deunionization in the US.

The benchmark analysis relies on a few assumptions, which seem to suggest a rather conservative role for the rising skill premium. First, it is assumed that the distribution of skills remained constant. While this seems a reasonable assumption for observed skills, it may not be readily extended to ability, x. In fact, the residual wage inequality has increased more than warranted by the rise in skill prices. Although the residual wage contains several factors of productivity, the worker-specific component seems to be, at least in part, responsible for the overall increase.[22] Since ability is not priced in the union, higher dispersion in ability relative to skill, σ_x/σ_s, would increase the effective wage compression within the union and lead to further deunionization. This could also explain the flatter union participation profile in 2007.

Second, it is assumed that the parameters related to the search and matching framework, including the bargaining powers, are constant. One might suspect that as the unionization rate declines, so does the power of collective bargaining. This too would lead to further deunionization. Nonetheless, the estimates show that the union wage premium has remained fairly stable during the period considered here, with perhaps a mild decline in the late 1990s. The implications of changing bargaining power for deunionization are therefore not expected to be large.

7. Deunionization and unemployment

Our model introduces an interesting channel by which a decline in unions can lead to a decline in the long-run frictional unemployment rate. Since union workers keep a larger share of the surplus, a union job is less desirable from a firm's point

[21] The implications for the studies that estimate the effect of deunionization on wage inequality are more subtle. Since these studies compute the difference between the estimates of wage compression effects in 2 years, the bias is likely to be smaller, even though the statistics are biased in each year.

[22] Using panel data, Haider (2001), for instance, shows that the share of individual factors in wage variance rose from 55% in 1978 to 70% in 1991.

of view than a non-union job. Prevalence of unions affects the expected return to posting a vacancy by changing the odds of matching to an ex post unionized worker. The size of this effect depends, in turn, on the union wage premium, i.e., the relative bargaining powers of the union and individual workers.

The impact of deunionization on unemployment in our model therefore has two dimensions. First, it raises the ex ante expected firm share in the bargaining and encourages firms to create additional vacancies. This leads to an increase in labor market tightness and, hence, the job-finding rate. Second, depending on the composition of skills in the union sector and the bargaining powers, the average union premium could change, creating an equilibrium effect on the return to vacancy. The latter, however, is limited here since the average union premium has remained stable in our computations as the aggregate unionization rate has fallen. The model predicts a decline in the steady-state rate of unemployment for 2007. Compared to the 1978 economy, the vacancy-unemployment ratio, θ, goes up by 9.8%, leading to a decline in the unemployment rate, from 6.0% to 5.59%.[23]

Some of the decline in the unemployment rate can be attributed to the increase in productivity alone, independent of the decline in unions. This effect, however, is negligible here because the technical change in our model is mean-preserving, in the sense that half of the workers enjoy an increase in productivity while the other half experience a decline in productivity. At the equilibrium, a return to posting a vacancy depends on the productivity of the average worker. Since the productivity of the average worker is relatively stable, technical change alone does not promote an additional incentive for the firms to post vacancies.[24]

8. Deunionization and wage inequality in retrospect

The upshot of this analysis is that the changes in the underlying productivity distribution and skill premium explain about 40% of the fall in the unionization rate. This is the major factor of deunionization, relative to other explanations in the literature.

The decline of the unions coincides with a period in which the US economy shifted away from sectors where unions were traditionally strong, such as the manufacturing sector, to sectors where unions are harder to organize, such as services.[25] Could this sectoral shift alone explain the observed decline in the unions? Our calculations indicate that the shifts *between* sectors predict a decline of 4.3% in union membership between 1973 and 1999, relative to a decline of 15.9% *within* industries at the 2-digit level.[26] Changes in industrial composition, therefore, account for 20% of deunionization in total.

Global forces are often mentioned as the culprits of deunionization (Reder, 1988). The increased competition in the labor market, either directly through outsourcing or indirectly through import substitution of labor-intensive products, could lead to deunionization. Baldwin (2003) argues, however, that the effect of international trade on labor unions was modest, with the largest impact being concentrated on the blue-collar jobs. This is consistent with the falling productivity of low-skill workers in the model. Although this research highlights technical change as the main cause of the rising skill premium, the results carry over to more general cases where skill prices are altered by, *inter alia*, increased competition in the labor market due to expansion of US trade or outsourcing.

Yet another factor that has been mentioned is the changes in the degree of competition in product markets. Larger mark-ups in oligopolistic markets are thought to foster rent-sharing incentives and pave the way to union organization. We are not aware of a quantitative study of this channel, but since our results indicate that an important fraction of deunionization in the US remains unexplained, investigating the connection between increased competition and deunionization would be a promising next step.

We considered the public sector to be outside our model; however, one could draw parallels between the public sector contracts, unionized or not, and the union wage contracts. Katz and Krueger (1991) find that the skill premium in the public sector remained stable during the 1980s, while it was rising rapidly in the private sector. This significantly diminished the capacity of the federal government to attract skilled workers, similar to the results of the model.[27]

9. Future directions

Although the model captures the main characteristics of unions, it abstracts from a few potentially interesting extensions toward a more general theory of unions. First, the relatively stable union wage structure for the time period analyzed led us to refrain from explicitly modeling the process that leads to this structure. Explaining why skill prices are compressed in

[23] This depends, in part, on our calibration of matching function elasticity, α. If we increase α to 0.8, for instance, the unemployment rate becomes more sensitive to changes in labor market tightness and declines to 5.46%.

[24] We calculated an upper bound of this effect on unemployment using a version of our model without unions. In this exercise the change in productivity alone causes the unemployment rate to drop from 6.03% to 5.96%.

[25] The cost of organizing a union could vary by industry, owing to such factors as geographical dispersion of production units, capital intensity, the size distribution of establishments, or local legislation.

[26] We mapped the 3-digit census coding to the 2-digit classification, as defined by the NBER. Due to the change in the census industrial classification system in 2000, the compositional analysis was confined to the years 1973–1999. Since the rate of unionization declined by 4% after 1999, our composition analysis probably would not be altered much by including the period after 1999.

[27] The developments in the public sector may have had implications for the private sector unionization rate, but this effect is expected to be trivial as the share of federal government in employment is around 3% and has declined by a total of 1.1% between 1978 and 2007, according to the BLS.

union establishments would contribute to an understanding of unions. Similarly, union workers are assumed to have higher bargaining power. This could be endogenized by introducing fixed factors of production, such as capital, that give unions the opportunity to expropriate infra-marginal returns *à la* Stole and Zwiebel (1996). Yet another valuable extension is to incorporate endogenous separations into the model, possibly as a bargaining tool for union workers. Union workers have intermittent employment patterns, with frequent but temporary layoffs. Explicitly modeling this phenomenon, possibly as rest unemployment as in Alvarez and Shimer (2011), would allow the researcher to address the differences in cyclical patterns of employment and wages between union and non-union sectors.

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Appendix A. Supplementary data

Supplementary data associated with this paper can be found in the online version at http://dx.doi.org/10.1016/j.jmoneco.2014.01.002.

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