

The Rising Skill Premium and Deunionization in the United States*

Ömer Tuğrul Açıkgöz[†]
University of Rochester

Barış Kaymak[‡]
Université de Montréal

Abstract

The union participation rate in the U.S. has declined rapidly from 34% in 1973 to 9.2% in 2007 while wage inequality has increased. In this paper we develop a parsimonious model of endogenous union membership that is consistent with (i) a hump-shaped union participation rate with respect to skill, (ii) positive and significant wage gains to union members, and (iii) a union wage premium that is decreasing in skill as observed in the data. Based on the premise that labor unions compress wages between skilled and unskilled workers, a rise in the skill premium encourages skilled workers to withdraw from the union, decreasing the unionization rate. If the rise in skill prices is also accompanied by a fall in the real wages of less skilled workers, firms become more reluctant to hire the relatively expensive union workers, reinforcing the decline in the unionization rate. We evaluate our model to measure the contribution of changing skill prices to deunionization in the U.S. The results indicate that the rising skill premium is responsible for about a third to a half of the decline in the rate of unionization. It has been argued that the declining union activity contributed to the recent rise in wage inequality by changing the labor force composition. We find this effect to be much smaller due to selection into union jobs.

Keywords: Skill Premium, Union Participation, Deunionization, Wage Inequality

J.E.L. Codes: J24, J31, J51, J63

*The authors would like to thank Árpád Ábrahám, Daron Acemoglu, Mark Aguiar, Mark Bils, David Card, Rui Castro, Yongsung Chang, Huberto M. Ennis, Raquel Fernandez, Juan Carlos Hatchondo, William Hawkins, Andreas Hornstein, Jay Hong, Thomas A. Lubik, Juan M. Sanchez as well as all seminar participants at the University of Rochester, Université de Montréal, the Federal Reserve Bank of Richmond, Econometric Society Summer and European Meetings 2009, Canadian Economic Association Meetings 2009, NBER Summer Institute 2009, Midwest Macro Meetings 2009 for valuable comments and discussions. Part of this research was conducted while Ömer Açıkgöz was visiting the Federal Reserve Bank of Richmond and we are grateful for the bank's financial support and hospitality. This research is funded in part by the Fonds de Recherche sur la Société et la Culture of Quebec.

[†]Department of Economics, University of Rochester, PO Box 270156, Rochester, NY-14627. E-mail: oacikgoz@troi.cc.rochester.edu

[‡]Department of Economics, Université de Montréal, C.P. 6128 succursale Centre-ville, Montréal, QC H3C 3J7. E-mail: baris.kaymak@umontreal.ca

1 Introduction

For the past three decades, the U.S. economy experienced a significant decline in the rate of unionization. The union participation rate for male workers in the private sector decreased steadily from 34% in 1973 to 9% in 2007,¹ and the percentage of workers whose wages are covered by a collective bargaining agreement decreased from 35% to 11% between 1978 and 2007 (Figure 1). Meanwhile, wage inequality increased sharply (Figure 2): the ratio of 90th to 10th percentiles of the wage distribution increased from 3.3 in 1973 to 5.1 in 2007 while the college – high school wage gap increased from 35% to 55%² (see also [Autor, Katz, and Kearney \(2008\)](#)).

The concurrence of these two trends launched a literature that studies the impact of the decline in union activity on rising wage inequality.³ Since unions favor a more egalitarian distribution of wages among their members, a decline in the ratio of workers covered by a collective bargaining agreement would presumably raise overall wage inequality. However, one could also argue that these egalitarian practices may themselves lead to a decline in the unionization rate. For instance, if unions achieve a more equal distribution of wages by compressing the return to skills, a rise in the skill premium in the non-union sector would raise the opportunity cost of being a union member for skilled workers. Provided that the benefits to being a union member do not rise along with the skill premium, skilled workers would opt out of the union. This is the direction of causality we investigate in this paper.

This reverse causality has received little attention in the literature with the exception of [Acemoglu, Aghion, and Violante \(2001\)](#), who provide a theoretical assessment of the argument above through skill-biased technical change (henceforth SBTC). They further argue that the withdrawal of skilled workers from the union would undermine the transfer of rents between different skill groups within the union, which in turn leads to the suspension of the union.

Although skilled workers’ decision to unionize is potentially an important factor in understanding the effect of SBTC on unionization, we believe that an equally important aspect is the selection into unions of workers at the lower tail of the skill distribution. Figure 3 shows the fraction of union members by skill deciles⁴ for 1978 and 2007. The union participation rate has an inverse-U shape, consistent with the broad view that union jobs are “hard to get” for low-skill workers

¹The unionization rate for women displays a similar but milder trend, whereas the unionization rate in the public sector increased slightly over this period. See [Freeman \(1988\)](#) and [Farber \(2005\)](#) for patterns of unionization in the public sector.

²Similar trends are also seen in the U.K. and France ([Machin and Reenen \(2007\)](#), [Machin \(2000\)](#) and [Kahn \(2000\)](#)). Many countries in continental Europe, most notably Germany and Italy neither experienced the rapid decline in collective bargaining nor the dramatic rise in inequality ([Pontusson \(2005\)](#)).

³See [Freeman \(1993\)](#), [DiNardo, Fortin, and Lemieux \(1996\)](#), [Card \(1998\)](#) and [Fortin and Lemieux \(1997\)](#), among others.

⁴Skills are predicted based on the returns to education and experience for non-union workers.

(Farber (1983), Abowd and Farber (1982), Card (1996)). How the selection of low-skill workers into the union responds to changing skill prices could have strong implications for the aggregate unionization rate. In addition, whether the rise in the skill premium is led by a decline in the wages of low-skill workers or a rise in the wages of skilled workers is important in providing a coherent theory of deunionization.

The main goal of this paper is to provide a theory of deunionization that is consistent with the observed relationship between skills, union participation and the wage distribution. To this end, we develop a parsimonious model of endogenous union participation with heterogeneous workers. We assume that bargaining collectively leads to higher bargaining power in wage negotiations relative to an individual worker. This delivers positive wage gains for all members, consistent with the evidence provided in the literature (Card (1996), Lemieux (1998), and Lewis (1986)). We also assume that the return to skill is lower in the union sector relative to the non-union sector, which leads to a union wage premium that is decreasing in skill. Under these two assumptions, the workers weigh the negotiation benefits of being a union member against the cost of transfers to the low-skill workers in the union. Essentially the workers with the highest productivity choose the non-union sector where they are well rewarded for their skills.

We model the firms' involvement in the formation of the union akin to the right-to-manage models in the literature (see Oswald (1985) for a survey). We assume that firms have discretion in their hiring decisions. Given the wage compression in the union sector, firms are not willing to hire workers whose productivity less than compensates for the union wage. This captures the notion that unionized jobs are not available to the lowest productivity workers. At the equilibrium, these workers sort into the non-union sector, since they would rather be employed at a lower wage than not be employed at all.

These two participation margins help capture the hump-shaped pattern of union participation in Figure 3. Suppose now that the rise in the skill premium is driven by a technical change that raises the productivity of high-skill workers. Then high-skill workers opt out of the union for higher wages in the non-union sector. Suppose in addition that the technical change deflates the value of certain skills possessed by low-productivity workers. Firms in this case would be reluctant to hire some low productivity workers at the relatively higher union wage. A rising skill premium in this case could potentially generate a large decline in the unionization rate. We find below that this scenario is a reasonable description of the change in the U.S. wage distribution.

The selection of workers from the middle of the skill distribution also severely limits the composition effect of deunionization on wage inequality. We find this effect to be much smaller than a naïve estimate that ignores selection. This is because when the selection is ignored, the estimated variance of union wages is particularly lower and that of non-union workers is particularly higher

relative to what they would be if union jobs were randomly allocated. This leads to an overestimation of wage compression in the union and might explain why the earlier studies have found larger effects of deunionization on wage inequality.

Before we evaluate the model to gauge the role of the rising skill premium on the unionization rate, we test our model by checking the predictions of the model on the cross-sectional distribution of union participation and wages by skill. In particular, we match the aggregate unionization rate for the years 1978-1980 given the observed returns to education and experience for union and non-union workers. We then compare the predicted union membership rates and the union wage premium by skill to the data and show that the model provides an accurate description of these moments. Since we explicitly allow for selection in unobservable skill factors in our model, we also compare our results with the estimates corrected for selection as provided in the literature.

Next, we use our model to evaluate the change in the rate of unionization in response to the rise in the skill premium. The model predicts a decline of 7-12 percent in the unionization rate, about a third to a half of the observed decline over the last thirty years.

Our findings highlight two important aspects of the deunionization experience in the U.S. First, we observe an increased resistance among firms to hiring low-skilled unionized workers leading to deunionization of these workers. This is due to the particular nature of the change in skill prices. The U.S. wage distribution displays a rise in wage inequality where the median worker and below experienced a decline in their real wage. Given the high union wage, this gives a disincentive for the unionized firms to hire these workers in the model and generates a decline in the unionization rate. We think that this is an important result, since the union participation rate in the data displays a decline almost everywhere in the skill distribution, which was pointed out by [Gordon \(2001\)](#) as a critique of SBTC as a potential cause of deunionization.

Second, the price of skill in the union sector also increased along with the skill prices in the non-union sector preventing perhaps a more rapid and sizable decline in the union activity caused by the rising skill premium.

In what follows, we briefly discuss the U.S. deunionization experience. We describe our model in section 3 and present conditions under which the rising skill premium leads to a decline in the unionization rate. In section 4 we estimate some of the model parameters and present our calibration. We provide an extensive discussion of our results in section 5. Section 6 concludes.

2 The Deunionization Experience in the United States and Alternative Explanations

An alternative theory of deunionization could emphasize the change in the composition of the economy away from sectors in which unions have been traditionally strong, such as the manufacturing sector, to sectors where unions are harder to organize, such as services.⁵ Table 4 shows union membership and union coverage by major industries for the years 1973 - 2007. The union presence is strongest in transportation, communication and utilities followed by manufacturing, construction and mining. In 1973, these industries had unionization rates of over 40%, which decreased drastically over the next three decades, to about 10-20% in 2007. On the other hand, in other sectors, such as agriculture, services and wholesale and retail trade, the unionization rates were 10% or less and the decline was more modest. The strong decline in unionization rates within each industrial sector indicates that there is more to deunionization in the U.S. than mere composition effects.

We calculated the composition effects at the two-digit level,⁶ keeping the industrial shares of employment constant at their 1973 level (1978 for union coverage) and updating only the sectoral unionization rates. Our results indicate that between 1973 and 1999, the change in industrial composition accounts for a 4.3% decline relative to a total decline of 20.2%. Similarly for union coverage, we calculate the composition effects to be 3.4% relative to a total decline of 17.2% since 1978. We conclude that the composition effects constitute a fifth of the decline in the unionization rate in the U.S. Our findings are in line with Farber (1990) and Farber and Krueger (1992), who estimate the composition effects to be around a fifth and a quarter of the total decline, respectively.

Farber and Western (2000) and Baldwin (2003) argue that the possibility of outsourcing of less-skill-intensive goods to developing countries not only eliminated the surpluses from production bargained with unions but was also used as a threat by firms to persuade union workers to vote against unionization in their plants. Overall, the increased competition in the labor market either directly through outsourcing or indirectly through import-substitution of labor intensive products could have been responsible for the decline of union activity; however, we find this argument to be in line with our model to the extent that it explains the decline in the wages of low-skill workers. Our results do not depend on why the skill premium rises and, therefore, carry over to more general cases where skill prices are altered by, *inter alia*, increased competition in the labor market due to

⁵The cost of organizing a union could vary due to, for instance, geographical dispersion of production units, the degree of capital intensity, the size distribution of establishments or local legislation.

⁶We mapped the 3-digit census coding to the 2-digit classification defined by the NBER. Due to changes in the census classification system, we confined the compositional analysis to the years 1973-1999. The overall rate of unionization declines by 4% after 1999; therefore, we think that our composition analysis would not be altered much by including these years.

expansion of U.S. trade or outsourcing.

An alternative explanation attributes deunionization to the anti-union efforts of Reagan in the U.S. and Thatcher in the U.K. While we recognize that the political agenda is important in influencing unionization rates, the timing of events suggests that the economic forces underlying deunionization were already underway before these political events and that perhaps they only amplified this process. The fraction of union members was already declining in the 1970s, years before Reagan's presidency. [Farber and Western \(2001\)](#) discuss the Reagan-era policies on labor unions and provide empirical evidence that the fall in the annual number of union elections actually precedes the appointment of the Reagan Labor Board in 1983. [Howell \(1995\)](#) discusses the political environment during the Thatcher era as a possible explanation for rapid deunionization in the United Kingdom.

In general we consider our work as supplementary to the literature on deunionization; however, we would like to point out that the existing literature explains the decline in unions for a particular group of workers, such as those working in the traded goods sector, whereas the unionization rate declined almost uniformly within industries, age and education groups.

In the next section, we present our model, which generates a decline in the unionization rate consistent with these facts.

3 A Model of Union Participation

For our analysis, we employ a search model *à la* Mortensen-Pissarides (MP).⁷ The search and matching frictions in this framework provides us with a natural surplus to be divided between the employer and the worker when they are matched. The rents come from the possibility of being unemployed at any point in time from the perspective of the worker and, similarly, the contingency of staying vacant from the firm's point of view. This allows us to introduce the collective bargaining process over the surplus as an alternative to bilateral bargaining between the firm and the worker.

The explicit matching process also allows us to use the strategic incentives at the worker-firm level to analyze the selection into unions. Union membership is endogenous in our model. Although there is a rich literature on unions and a wide variety of models of unions, all of them have unions by assumption. By contrast, our model features a union formed by agents who have incentives to join, and it is the composition of the workers in the union that determines union wages. To the best of our knowledge, this is the first model of endogenous union membership in the literature.

⁷Standard references are [Mortensen and Pissarides \(1994\)](#) and [Pissarides \(2000\)](#).

3.1 Environment

There is a continuum of workers with measure 1 and a large measure $N \gg 1$ of firms. We assume that each worker is endowed with a time-invariant productivity $(s, x) \in \mathcal{S} \times \mathcal{X}$ with joint distribution $(s, x) \sim F(., .)$. *Skill* s represents the productivity level observed by the firms, union and the econometrician alike. *Ability* x of the worker is independent of s and is evaluated by the firms but not the union. The ability component is also not observable by the econometrician. We also assume a representative sector and a representative union.

3.2 Preferences and Technology

We assume that workers are risk-neutral and they maximize

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \delta^t c_t$$

subject to relevant constraints. Here $0 < \delta < 1$ denotes the subjective discount factor of the worker and c_t is the consumption at time t . There are no savings; therefore, all earnings are consumed in each period.

At each point in time, each worker i is either employed or not. When employed, the worker earns wage w_{it} , which depends on his productivity and his union status. When unemployed, he receives the unemployment benefit b . As will be made clear later, in equilibrium, there is no uncertainty as to how much a worker would earn should he be employed.

All firms are *ex-ante* identical and they maximize the discounted profits,

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \delta^t \pi_t$$

subject to the relevant constraints. There is free entry to the market. Should a firm decide to post a vacancy, it has to incur a fixed cost of κ . When a vacant position is filled, the firm-worker pair produces

$$f(s_i, x_i) = \exp(\psi_t(s_i + x_i)),$$

where $s_i + x_i$ is the productive skill of the worker i , and ψ_t captures the productivity of skill at time t . The profit from a filled position is

$$\pi_t = f(s_i, x_i) - w_{it}$$

We abstract from potential match-specific variations in productivity. We take this assumption

into account when we calibrate our model.

3.3 Matching and Recursive Formulation

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

$$m(v_t, u_t) = \eta u_t^{1-\alpha} v_t^\alpha$$

We define $\theta_t \equiv v_t/u_t$ as labor market tightness. The CRS assumption allows us to express the relevant matching variables in terms of θ . In particular we let

$$p(\theta_t) \equiv m(v_t, u_t)/u_t = m(\theta_t, 1) \quad \text{and} \quad q(\theta_t) \equiv m(v_t, u_t)/v_t = m(1, \theta_t^{-1}) = p(\theta_t)/\theta_t$$

These denote the probability of an unemployed worker being matched with a firm and the probability of a vacant position being matched with a worker respectively under a law of large numbers. Note that the matching parameters do not depend on a worker's skill level. We assume that the firm cannot direct its search toward a specific skill group.⁸

Workers' Value Functions

We are now ready to define the value functions of the agents in the economy. We drop the time subscript, since we are interested in the steady state of the economy. For what is to follow, let $M^w(s, x)$ be the value of a match for the worker and $M^f(s, x)$ the value of a match for the firm. These values are determined by strategic interaction between the firm and the worker at the point of the match.

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

$$W^n(s, x) = w^n(s, x) + \delta[\lambda U(s, x) + (1 - \lambda)M^w(s, x)] \tag{1}$$

Each worker receives the competitive wage $w^n(s, x)$ and separates next period with an exogenous probability of λ , in which case he gets $U(s, x)$. With probability $(1 - \lambda)$ the match is retained.

⁸Market segmentation by skill does not change our results, even when we calibrate our parameters to vary by skill groups.

Similarly, the value of a union job is,

$$W^u(s, x) = w^u(s) + \delta[\lambda U(s, x) + (1 - \lambda)M^w(s, x)] \quad (2)$$

Note that the union wage depends only on the skill level $s \in \mathcal{S}$. Since union wages are determined collectively at a larger scale, we think it is plausible that individual firms are better than unions in evaluating their employees individually. Given our assumption of independence between s and x , we allow any productivity trait that can be projected on easily observable credentials, such as education, experience or seniority, to be priced into the union wage.

The value of unemployment for a worker with skills (s, x) is represented by:

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

where b is the flow benefit to being unemployed, possibly consisting of the value of leisure as well as any unemployment benefits the worker must receive. With probability $p(\theta)$, the worker is matched with a firm and gets $M^w(s, x)$. If the match breaks without an agreement or if he is not matched with a firm (with probability $1 - p(\theta)$), he remains unemployed.

Firms' Value Functions

The values of a filled position by a non-union worker and a union worker are, respectively,

$$J^n(s, x) = f(s, x) - w^n(s, x) + \delta[\lambda V + (1 - \lambda)M^f(s, x)] \quad (3)$$

$$J^u(s, x) = f(s, x) - w^u(s) + \delta[\lambda V + (1 - \lambda)M^f(s, x)] \quad (4)$$

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:

$$V = -\kappa + \delta \left(q(\theta) \int_{\mathcal{S} \times \mathcal{X}} M^f(s, x) dF(s, x) + (1 - q(\theta))V \right) \quad (5)$$

A vacancy is matched with a worker at the rate $q(\theta)$ every period. With probability $(1 - p(\theta))$ the firm stays vacant.

Value of a Match and Two-Sided Selection into Unions

We can now define the match values $M^f(s, x)$ and $M^w(s, x)$. When a vacancy is matched to a worker, the firm observes the worker's skills $(s, x) \in \mathcal{S} \times \mathcal{X}$ and both parties observe union wages $w^u(s)$. Then, they play a non-cooperative game in which the worker moves first and decides whether

to join the union, and the firm decides whether to hire the worker or stay vacant, conditional on the worker's decision. Let $\mathcal{G}(s, x)$ represent the extensive-form non-cooperative game⁹ between a firm and a worker of skill (s, x) . Figure 5 represents the game tree, decision nodes and payoffs. The game specified above has a sub-game perfect equilibrium in pure strategies, since we can always find a pair of strategies that survive backward induction.

Let $M^f(s, x)$ and $M^w(s, x)$ be the sub-game perfect equilibrium payoffs¹⁰ of the above game for the firm and the worker respectively.

The reason we consider the timing above requires clarification, since it is crucial for the type of Nash equilibria we are interested in. First, note that a simultaneous-play game features multiple strategic outcomes, one of which Pareto-dominates the other. In particular, we can show that if the worker has sufficiently low productivity, he would not be hired at the inefficient equilibria, whereas in the alternative equilibrium, the worker is employed regardless of his productivity level. In fact, if we reversed the sequence of decisions, we would pick out the inefficient outcome. To see this, fix a union wage that is higher than the competitive wage, and consider a worker with sufficiently low productivity. Assume that the firm moves first. Conditional on being hired by the firm, the worker would choose to join the union because of the wage gains involved. If the wage gain to being a union member exceeds the firm's share of the surplus (which would occur with a sufficiently low productivity), the firm would not hire this worker in the first place because the union wage would be higher than the worker's productivity. However, an outcome where the worker chooses not to unionize and bargains competitively with the firm would be a Pareto improvement for both agents. This is indeed the equilibrium outcome when the worker moves first.

The ordering of the decisions we adopt might seem odd, since the firm may potentially refuse to hire a worker if he chooses to join the union. This assumption is in fact innocuous for two reasons.

⁹Formally, we define the extensive-form game with perfect information for skill pair (s, x) as,

$$\mathcal{G}(s, x) = \langle \mathcal{T}, \{d_i\}_{i \in \{w, f\}}, a, \{\pi_i^{s, x}\}_{i \in \{w, f\}} \rangle$$

where

- Game tree \mathcal{T} is a tuple $\langle N, D, p \rangle$ where N is the set of all nodes $N = \{0, U, N, (U, H), (U, NH), (N, H), (N, NH)\}$, $D \subset N$ is the set of decision nodes $D = \{0, U, N\}$ and $p : N \setminus \{0\} \rightarrow N$ is the node function that maps each node to the first node that precedes it.
- d_i for each $i \in \{w, f\}$ is a set of decision nodes where agent i gets to play. ($d_w = \{0\}, d_f = \{U, N\}$)
- a is a function that maps each decision node to a set of actions. ($a(U) = a(N) = \{\text{Hire}, \text{Not Hire}\}$, $a(0) = \{\text{Union}, \text{Non-union}\}$)
- $\pi_i^{s, x}$ for each $i \in \{w, f\}$ and each $(s, x) \in \mathcal{S} \times \mathcal{X}$ is a function that maps each terminal node to the payoff received by player i , i.e. $\pi_f^{s, x}(U, H) = J^u(s, x)$, $\pi_f^{s, x}(U, NH) = V$, $\pi_f^{s, x}(N, H) = J^n(s, x)$, $\pi_f^{s, x}(N, NH) = V$ and $\pi_w^{s, x}(U, H) = W^u(s, x)$, $\pi_w^{s, x}(U, NH) = U(s, x)$, $\pi_w^{s, x}(N, H) = W^n(s, x)$, $\pi_w^{s, x}(N, NH) = U(s, x)$.

¹⁰Given the equilibrium wage structure, these payoffs are unique, yet the equilibrium strategies are unique almost everywhere on $\mathcal{S} \times \mathcal{X}$ with respect to measure F .

First, the firm never exercises this option at the equilibrium. In anticipation of the firm's decision, the worker chooses not to join the union and works at the competitive wage. Second, one could equivalently formulate a model with wage posting as follows. Suppose there are two sectors: union and non-union, and workers target a sector for their job search given their skill group. Let each entering firm choose a sector and then post wages for each skill level. Unionized firms would find it optimal not to post any vacancies for low-skill workers since the posted wage determined by the union would be too high for these skill groups. Since the non-union firms post wages competitively, they would end up hiring these workers. Both of these models would equivalently allow us to capture the inverse-U-shaped unionization rate mentioned earlier.

3.4 Wage Determination

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

$$w^n(s, x) \in \arg \max \beta \log[W^n(s, x) - U(s, x)] + (1 - \beta) \log[J^n(s, x) - V]$$

For the specification above, $w^n(s, x)$ satisfies,

$$\frac{W^n(s, x) - U(s, x)}{\beta} = \frac{J^n(s, x) - V}{1 - \beta}$$

It can be shown, by straightforward algebra that,

$$w^n(s, x) = \beta f(s, x) - \beta(1 - \delta)V + (1 - \beta)(1 - \delta)U(s, x) \quad (6)$$

We finally let $b \equiv \rho w^n(s, x)$ for agents who bargain competitively where $\rho \in (0, 1)$. It is important to note that the first-order condition on the Nash bargaining does *not* involve an indirect effect through the unemployment benefit. The bargaining parties take it as given,¹¹ as opposed to being a constant fraction of market wage, while evaluating the outside option of the worker. This allows us to simplify the wage functions and obtain a functional form that can be used for empirical analysis.

Unionized workers and firms hiring them bargain collectively. We can think of this as the firm leader and union leader bargaining over the total surplus. We assume that the union has a higher bargaining power than an individual worker and distributes the aggregate union surplus to workers. We also assume that unions compress wages: the return to skills in the union is lower than that in the competitive sector. We impose the following union wage scheme as a means of distributing the

¹¹This is not an unreasonable assumption when we consider that a worker-firm match has measure zero.

surplus:

$$w^u(s) = \phi_0 \exp(\phi_1 s) \quad (7)$$

where $\phi_1 \leq \psi$ is the exogenously fixed return to skill in the union.¹² Let $\mathcal{U} \subset \mathcal{S} \times \mathcal{X}$ denote the set of values for $(s, x) \in \mathcal{S} \times \mathcal{X}$ for which the worker would choose¹³ to be a union member. The union bargaining with union weight $\gamma \in (0, 1)$ is represented by the following Nash bargaining problem:

$$\max_{\phi_0} \gamma \log \left(\int_{\mathcal{U}} [W^u(s, x) - U(s, x)] dF(s, x) \right) + (1 - \gamma) \log \left(\int_{\mathcal{U}} [J^u(s, x) - V] dF(s, x) \right) \quad (8)$$

Similar to the workers bargaining competitively, we let $b \equiv \rho w^u(s)$ for the union workers. The reason we consider a wage scheme as above deserves some attention. By the linear nature of the problem above, we have an indeterminacy as to how the total surplus is distributed within the union. Suppose \bar{w}^u is the wage level when we make the quite extreme assumption that every union member is paid the same wage. We can show that any mean-preserving spread $\tilde{w}^u(s, x)$ around \bar{w}^u , i.e. $\int_{\mathcal{U}} \tilde{w}^u(s, x) dF = \bar{w}^u$, also satisfies the bargaining first-order-condition. Second, the way we choose to distribute the surplus is both empirically and analytically tractable. We will later show, in the analysis section, that (7) has the same functional structure as the competitive wage function (12); i.e. it is log-linear in skills.

3.5 Equilibrium

The law of motion¹⁴ for unemployed workers implies a steady-state unemployment of

$$u = \frac{\lambda}{p(\theta) + \lambda} \quad (9)$$

At the steady state, the number of vacancies equals

$$v = \frac{\lambda \bar{N}}{q(\theta) + \lambda} \quad (10)$$

where \bar{N} is the measure of firms operating at the steady state.

The equilibrium in this economy is defined in the standard way:

Definition 1 *A steady-state equilibrium with unions consists of the wages $w^u : \mathcal{S} \rightarrow \mathbb{R}_+$, $w : \mathcal{S} \times \mathcal{X} \rightarrow \mathbb{R}_+$, extensive-form games $\mathcal{G}(s, x)$, value functions $M^f, M^w, J^u, J, W^u, W^n, U : \mathcal{S} \times \mathcal{X} \rightarrow \mathbb{R}$,*

¹²Later we show that wages for non-union workers have a similar parametric form.

¹³In equilibrium, this set is induced by the equilibrium strategies for $\mathcal{G}(s, x)$.

¹⁴The evolution of the measure of unemployed agents is represented by $u_{t+1} - u_t = \lambda(1 - u_t) - p(\theta_t)u_t$.

$V \in \mathbb{R}$, and labor market tightness $\theta \in \mathbb{R}_+$, such that
 Given w^u and w^n ,

1. $M^f(s, x)$ and $M^w(s, x)$ constitute the sub-game perfect equilibrium payoffs of the game $\mathcal{G}(s, x)$ for each $(s, x) \in \mathcal{S} \times \mathcal{X}$.

Given equilibrium strategies for \mathcal{G} ,

2. Union Wages: w^u is determined by collective bargaining (8) for each $s \in \mathcal{S}$.
3. Non-union wages: w^n is determined by individual bargaining (6) for each $(s, x) \in \mathcal{S} \times \mathcal{X}$.
4. Optimal vacancy posting: $V \geq 0$.
5. Free entry: $V \leq 0$.
6. Labor market tightness: $\theta = v/u$ where u satisfies (9) and v satisfies (10).

Consistency

7. Wages w^u , w^n and the equilibrium strategies for \mathcal{G} are consistent with each other.

3.6 Analysis and Empirical Implications

We start our analysis of the equilibrium with the characterization of the employed and unionized workers. There are essentially four important conditions on the productivity of a worker. The first two are employability margins dictated by the firm. For a worker to be hired, the firm requires that the value of a position filled by a worker must be greater than the value of keeping the position vacant for another period. Since the value to the firm of a filled position depends on the negotiated wage, this requires that $J^n(s, x) \geq V$ must hold for all non-unionized workers, and $J^u(s, x) \geq V$ for all union workers. The first condition determines the employability margin as a function of s and x . The latter condition is more demanding at the equilibrium since the union workers enjoy higher wages in general. As we will demonstrate shortly, this condition will set a lower bound for the productivity of union workers.

The worker's decision similarly introduces two margins. First, in order for the worker to accept a position, the value of having a job should be higher than staying unemployed for another period. This requires that $W^n(s, x) \geq U(s, x)$. The second condition is induced by the worker's decision to join the union and requires that $W^u(s, x) \geq W^n(s, x)$.

The conditions above define two critical selection thresholds. To derive these thresholds, first note that using the equilibrium condition $V = 0$ along with equations (3), (1) and (6), the value of unemployment can be expressed as a fraction of productivity:

$$U(s, x) = \frac{\beta\rho(1 - \delta(1 - \lambda)) + \beta\delta p(\theta)}{(1 - \delta)[(1 - \rho(1 - \beta))(1 - \delta(1 - \lambda)) + \beta\delta p(\theta)]} f(s, x) \quad (11)$$

Substituting the expression above in (6), wage function in the non-union sector is:

$$w^n(s, x) = \frac{\beta(1 - \delta(1 - \lambda)) + \beta\delta p(\theta)}{(1 - \rho(1 - \beta))(1 - \delta(1 - \lambda)) + \beta\delta p(\theta)} f(s, x) \quad (12)$$

$$= C(\beta) \exp(\psi(s + x)) \leq f(s, x), \quad (13)$$

where $0 < C(\beta) < 1$ is the fraction of production retained by the worker in wages and it is increasing in β . This implies that for any filled position, the firm claims the remainder $1 - C(\beta)$ fraction of the production. Using equation (5), the value to a filled non-union position is simply:

$$J^n(s, x) = \frac{f(s, x) - w^n(s, x)}{(1 - \delta(1 - \lambda))} = (1 - C(\beta))f(s, x).$$

But this expression is non-negative for all values of s and x , implying that, at the equilibrium, a filled non-union position is always preferable to keeping the position vacant for another period from the firm's perspective.¹⁵ This is a direct consequence of zero profit condition for posted vacancies at the equilibrium and our assumption that the flow value of unemployment is proportional to the worker's productivity which allows us to express wages as a fraction of productivity. It is straightforward to show in a similar manner that the optimality of the match is mutual, i.e., $W^n(s, x) \geq U(s, x)$ holds for all values of s and x ; therefore, it is mutually beneficial not to break the match for any worker firm pair.

We now turn to the selection conditions on the unionized workers. Conditional on being hired, a worker prefers to join the union if $W^u(s, x) \geq W^n(s, x)$, or equivalently when the union wage is higher than the competitive alternative $w^u(s) \geq w^n(s, x)$. With our functional form assumptions, given a union wage policy (ϕ_0, ϕ_1) , the union wage is higher than the competitive wage if and only if $(\psi - \phi_1)s + \psi x \leq \ln \phi_0 - \ln C(\beta)$. When union wage policy has a compressed structure, $\phi_1 < \psi$, this condition is satisfied only for the lower values of s and/or x .¹⁶ Therefore, the first implication of our model is that workers with higher productivity choose not to be a part of the union for the skill is better rewarded in the competitive market. Second, conditional on having a high value of

¹⁵Note that the equality is only possible at the limit when $s + x \rightarrow 0$.

¹⁶Note that the union's budget constraint (8) implies that whenever $\phi_1 < \psi$, we also have $\phi_0 > C(\beta)$.

observable productivity s , the workers who prefer to join the union have lower unobserved ability, x .

To see the firm's role in the composition of unions, note that, given the union wage policy, (ϕ_0, ϕ_1) , the firm agrees to offer a union position if and only if $J^u(s, x) \geq V$, or equivalently if the worker's productivity is higher than the union wage, $f(s, x) \geq w^u(s)$. Any worker who does not meet this requirement is not desirable by the firm, should he choose to join the union. Since the worker is better off employed than not, he would choose to bargain individually in our game theoretic framework. With the functional form assumptions the firm has a positive surplus from a match with a union worker if $(\psi - \phi_1)s + \psi x \geq \ln \phi_0$. Once again, with $\phi_1 < \psi$, this condition defines a minimum requirement for skill s (or x), conditional on x (or s) which a worker has to meet in order to be a union member. The following proposition summarizes the skill composition of union workers.

Proposition 1 *Given the union wage policy (ϕ_0, ϕ_1) , a worker joins the union if and only if $\ln \phi_0 \leq (\psi - \phi_1)s + \psi x \leq \ln \phi_0 - \ln C(\beta)$.*

For a given level of ability x_o , the selection conditions above define the following two thresholds,

$$\underline{s}(x_o) = \frac{\ln \phi_0 - \psi x_o}{\psi - \phi_1} \quad (14)$$

$$\bar{s}(x_o) = \frac{\ln \phi_0 - \ln C(\beta) - \psi x_o}{\psi - \phi_1} \geq \underline{s}(x_o), \quad (15)$$

which constitute the skill composition of the union workers at the equilibrium. The latter condition corresponds to the level of skill for which, the productivity of the worker is equal to the union wage; therefore, the firm is indifferent to hiring the worker.

The above characterization of unionized workers is partial since we have taken the union wage as given. At the equilibrium, union wages implied by the skill composition of union workers are consistent with the union wage function used to determine the skill composition of unions in proposition 1. To characterize the union wage function, recall that the union bargains for all workers that join the union and distributes the surplus according to the wage policy defined by equation (7). The following equality shows the budget constraint of the union.

$$\int_{\mathcal{U}} C(\gamma) \exp(\psi(s + x)) dF(s, x) = \int_{\mathcal{U}} \phi_0 \exp(\phi_1 s) dF(s, x). \quad (16)$$

The left side of this equation is the part of the collective marginal product retained by the union at the solution to (8). With linear utility, this is equivalent to the sum of all individual bargaining outcomes for union workers assuming that they each have a bargaining weight of γ .

Since $C(\gamma) > C(\beta)$ when $\gamma > \beta$, union workers keep a larger portion of their product than they would were they to bargain individually and pool their wages. The second part of the equation is the total union wage bill. Given an exogenous skill compression policy, ϕ_1, ϕ_0 can be determined by the equation above. Equilibrium is reached when union participation can be rationalized by union wages as calculated above.

Union Wage Premium

The union wage premium for a worker with skill set (s, x) is $w^n(s, x) - w^u(s) = \ln \phi_0 - (\psi - \phi_1)s - \ln C(\beta) - \psi x$. For a given value of ability x_o , the union premium attains its maximum at the lower skill threshold ($\underline{s}(x_o)$) and equals $-\ln C(\beta)$. The lowest observed union premium is zero for the worker at the upper margin. This is consistent with the findings in the literature where low-skill workers in the union have a much higher wage gain compared to skilled workers in the union. The observed union premium conditional on s , however, transcends both of these bounds. Due to selection, the average value of x conditional on being a union member will be lower than the unconditional average for low enough values of observed skill s . This will generate an artificially high wage gain for low values of observed skill and artificially low wage gains, in fact negative wage gains, for highly skilled workers.

Rising Skill Premium

To see the implications of a rise in the skill premium for the rate of unionization, we consider two different scenarios. In the first scenario, the rise in the price of skilled labor is accompanied by a fall in the productivity of the less skilled. This is shown in Figure 6a as a rotation of $\ln f(s, x_o)$ for a fixed value of x_o . Since wages in the non-union sector are log-linear in productivity, the wage curve for this sector also rotates. Suppose that the skill price within the union, ϕ_1 , is fixed. Then unionized workers with the highest productivity will choose to opt out of the union, since the cost of wage transfers within the union increases relative to gains obtained through higher bargaining power. This results in an inward shift of $\bar{s}(x_o)$. Similarly, the unionized workers with the lowest productivity are not going to be able to stay in the union since their productivity now less than compensates for the high union wage, and $\underline{s}(x_o)$ will increase, further reducing the size of the union. This effect is *ceteris paribus*; in particular, we keep the union wage function fixed. But in this scenario, the average productivity of unionized workers is not likely to move much, since both thresholds are moving inward, rendering the effect on the union wage schedule second order.

In the second scenario, we consider an across-the-board rise in the skill price, where the rise in wages of the skilled is more than proportionate to the rise in wages for the unskilled, raising the skill premium. This scenario is depicted in Figure 6b. Once again productivity and the competitive

wage function shift up, which results in a downward shift of $\bar{s}(x_o)$. However, since productivity is higher for all workers, low-skill workers are now more profitable to the firm relative to their union wage. Firms hire some low-skill union workers who were not profitable before, which decreases the threshold productivity to join the union to $\bar{s}'(x_o)$. The relative skill composition of unionized workers declines, and the partial effect on the rate of unionization remains second order, depending on the distribution of skill.

A relaxation of wage compression within the union has effects similar to those of the decreasing skill premium. An increase in the return to skill ϕ_1 for union workers without an accompanying increase in productivity makes the union more attractive at the upper margin. The effect on low-skill workers' union participation depends crucially on whether this increase comes about with rising wages for all or at the expense of low-skill workers. Two scenarios are again possible as above: one where the unionization rate is not much affected or one where it substantially increases, respectively.

The impact of combining the two effects depends a great deal on the quantitative analysis. Both of the effects, in isolation, have the potential of increasing or decreasing unionization rates depending on the composition of the workers in the union and the overall distribution of skills and ability. In the next section, we present the empirical analysis and quantify these effects.

4 Empirical Analysis

We evaluate our model economy to reproduce the labor market conditions and unionization rate of 1978 - 1980. We calibrate the parameters related to search and matching frictions and estimate the skill prices in the union and non-union sectors as well as the distribution of skills in the labor force. We compare the model's predictions with the selected labor market facts such as union participation and the union wage premium by skill for the years 1978-1980. We then apply the estimated changes in the skill price, ψ , and the wage compression, ϕ_1 , for 2005-2007 to examine the average unionization rate and changes in distribution of union participation.

4.1 Calibration

We set the time period for our analysis to a month and therefore use a discount rate of $\delta = 0.99^{1/3}$ as is standard in the literature. We choose the vacancy cost, κ , to normalize the equilibrium labor market tightness θ to unity. When $\theta = 1$, the probability of being matched with an employer is η . We set $\eta = 0.32$ to target the average duration of unemployment in 1978, which is 3.09 months. Given the job finding rate, we set the separation rate to $\lambda = 0.02$ to match the average unemployment rate of 6.03% for the years 1978-1980 as described by equation (9). We let $\alpha = 0.5$.

Since the Hosios efficiency condition does not hold in our model economy, the relationship between α and Nash bargaining weight β does not apply. We set $\rho = 0.4$ as reported by Shimer (2005) to be the fraction of earnings enjoyed when unemployed. In our model this captures utility from both consumption and leisure. We assume that s and x are independent and have a normal distribution. We set the mean levels of s and x to zero. This implies that when the skill premium, ψ , rises, wages decrease for half of the workers, comparable to the 57% observed in the data. The first panel in Table 1 shows a summary of calibrated parameters.

4.2 Estimation

We now turn to the estimation of the skill prices and the degree of wage compression for unionized workers. We identify the crucial parameters of our model as follows. We first estimate our parameters using an auxiliary model under the assumption that union membership is random, i.e., there is no selection into union jobs. Some of these estimates are biased when there is selection. We then use the selection implied by our model to gauge the bias and thereby uncover the underlying true parameters. Our estimates ensure that if one were to estimate these parameters using model simulated data, ignoring selection, the estimates would coincide with those observed in the data.

Let $j \in \{n, u\}$ denote the non-unionized and unionized categories, respectively. Marginal productivity of worker i at time t is given by,

$$\log y_{it} = X_{1it}\Gamma_{jt} + X_{2it}\Psi_{jt} + \varepsilon_{ijt} \quad (17)$$

where, X_1 is a vector of skill characteristics and X_2 is a vector of controls for non-skill-related characteristics. Note that skill prices vary across the two sectors. When there is no selection into union jobs $E[\varepsilon_{iut}|X_{1it}, X_{2it}] - E[\varepsilon_{int}|X_{1it}, X_{2it}] = 0$, i.e., conditional on the observable skills, the union workers are perfectly substitutable with non-union workers. This assumption allows for a consistent estimation of skill prices Γ_{jt} in the two sectors.

When there is selection into union jobs, this assumption is violated. In particular, the expression above is positive for low values of observed skill and negative for high values of observed skill. This results in overestimation of the skill premium in the non-union sector and underestimation of that in the union sector. Nevertheless we will outline an estimation procedure that will identify the parameters of the model under the exogeneity assumption above, noting the direction of the selection bias wherever applicable. We will then use the selection implied by the model to correct these estimates.

Estimation of the Skill Distribution

We begin by estimating an observable skill composite for workers, corresponding to s in our model, based on the observed prices in the non-union sector. A skill composite for a worker priced at time t is obtained by estimating the equation (17) above for non-unionized workers and calculating the prediction,

$$\hat{s}_{it} = X_{1it}\hat{\Gamma}_{nt}$$

Note that by definition the time t price of the composite skill calculated at time t is always one. Therefore, we normalize ψ to be one for the years 1978-1980. We focus primarily on education and experience as measures of skill. We categorize education 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. We then predict the skill index including a full set of interaction dummies for each year of potential experience (age - years of education - 6) and each education category in X_1 . We include dummy variables for race, marital status and survey year in the controls.

The construction of the composite skill as outlined above is not consistent when there is selection as modeled here. The estimated non-union prices for low skill categories, such as low educational attainment and experience, are particularly low since the workers with high unobservable skills in this category join the union, leaving the low ability workers in the non-union sector conditional on observed skill. Similarly the observed prices are unusually high for high levels of observed skills. Hence, the estimated skill premium using the non-union workers overestimates the true skill premium. This yields a more disperse skill distribution relative to the underlying true distribution of observed skills.

We use the distribution of the estimated skill index for all workers to identify σ_s . The estimated value is 0.29, which is consistent under random union participation but biased upwards under selection as described above. When we evaluate our model, we will choose σ_s such that a similar estimation carried out in the model yields an estimate of 0.29.

Once the observed component of wage variance is found, standard deviation of the unobserved component, σ_x , can be deduced as the residual wage variance. Since the wage in general contains variation outside the model, for instance due to differing histories of job search or match specific effects, we limit our analysis to the fraction of the wage variance that is due to individual skills. Using the Panel Study of Income Dynamics (PSID), [Haider \(2001\)](#) estimates a model of earnings where he allows for individual fixed effects as well as heterogeneity in life cycle profiles of wages. His findings indicate that approximately 57% of the variance in wages can be attributed to individual characteristics for the years 1978 - 1980 (See Table 5 and Figure 7 in [Haider \(2001\)](#)). More recently [Woodcock \(2008\)](#) estimates this component to be about 53% (See Table 2 in [Woodcock \(2008\)](#)) using data from the Longitudinal Employer-Household Dynamics Program of the U.S. Census. We

therefore assume that the wage variation corresponding to our model is 55% of the total variation in the data, which equals 0.16 in 1978-1980. In Section 5.4 we analyze the sensitivity of our estimates and results to this assumption.

Note that the bias in the estimation of the skill prices also spreads the values of skill deciles but does not affect the reported union participation rates within these deciles. Therefore the union participation rate by deciles as depicted in Figure 3 is consistent.

Estimation of Wage Compression in the Union Sector

To estimate the degree of wage compression, we take the predicted composite skill index for unionized workers and project their actual wage on their predicted skills and other control variables.

$$\log w_{itu} = \phi_t \hat{s}_{it} + X_{2it} \Psi_{ut} + \epsilon_{itu} \quad (18)$$

The coefficient $\phi_t < 1$, measures the degree of compression in the return to skill in the unionized sector. We estimate the wage compression to be 48% ($\hat{\phi} = 0.52$) for the years 1978-1980. Under selection, this procedure overestimates the wage compression by the union (underestimates ϕ) since the skill prices in the non-union sector are overestimated due to the bias in \hat{s}_{it} .

The estimated compression for the years 2005-2007 is 35%. The returns to skill in the unionized sector have increased relative to the prices in the non-unionized sector. This creates an incentive for high-skill workers to join the union, which mitigates the deunionization effect generated by the rise in the skill premium. We will incorporate this in our analysis in the next section.

Estimation of the Change in the Skill Distribution

To capture the change in the skill distribution, we predict the skill index for the years 2005-2007 based on the prices estimated for the years 1978-1980. In general, denote the skill composite of person i , based on fixed time t_0 prices by

$$\tilde{s}_{it,t_0} = X_{1it} \hat{\Gamma}_{nt_0}$$

The cross-sectional distribution of \tilde{s}_{it,t_0} relative to \hat{s}_{it_0} gives us the change in the composition of skills from t_0 to t . The standard deviation of \tilde{s}_{it,t_0} is 0.31, slightly higher than the 0.29 in 1978-1980. This estimate also overshoots the true standard deviation of observed skill in 2005-2007 in the same way.

The change in the standard deviation of ability x can not be readily obtained without further assumptions. Haider (2001) reports a rise of approximately 70% in wage variance that is due to individual characteristics from 1978 to 1991. We are not aware of a comparable study for more

recent years. We therefore report our results under two scenarios which we consider to be bounds on the rise in persistent wage inequality. First we assume that the proportion of wage variance attributable to personal skills remained at 55% of wages throughout our sample. At the other extreme, we assume that all of the rise in wage variation is due to changing composition and prices of skills in the labor force. The total variance in our data increases from 0.29 to 0.46. Under the first scenario we set our targets for wage variance to 0.16 ($=0.55 \times 0.29$) in 1978 and 0.25 ($=0.55 \times 0.46$) in 2007. In the second scenario, our target wage variance for 2005-2007 is 0.33 ($=0.16 + (0.46 - 0.29)$).

Note that the rise in the variance of wages comes from *(i)* rising skill prices, *(ii)* changing skill composition and *(iii)* changing union composition. The model takes all of these into account when matching the variance figures reported above.

Estimation of the Change in the Skill Premium

The change in skill prices from time t_0 to t is identified by the difference between the distributions of $\tilde{s}_{it_0,t}$ and \hat{s}_{it} . This can be measured by regressing actual wages of non-union workers at time t on their predicted skills based on t_0 prices.

$$\log w_{itn} = \psi_t \log \tilde{s}_{it} + X_{2itn} \Psi_{tn} + \epsilon_{itn}$$

The estimate of the rise in the skill premium is 15.3%. The estimate of the change in the skill price is also inconsistent under the selection but the bias is of second order. Since the estimated skill prices in both years are biased upwards, the direction of bias in their ratio depends on the size of the bias in each year. In our case, the selection bias in 2005-2007 is smaller since there is less unionization in the economy and the selection is weaker, i.e. the graph of union participation by skill is flatter. This implies that the actual rise in the skill premium is slightly higher than 15.3%.

Individual and Collective Bargaining Power in Wage Negotiations

The choice of the bargaining powers, γ and β , is not straightforward. It is customary to assume that workers and firms have equal power in the case of individual bargaining. The literature provides little guidance on the bargaining powers of unions and individual workers relative to the employers'. The relative values of these bargaining parameters have a direct effect on the rate of unionization and the union wage premium. We aim to choose these two parameters to match the collective bargaining rate of 34.2% in 1978, taking into account that they interact with each other in the following way: conditional on the distribution of skills and a fixed value of β , the graph of the unionization rate as a function of γ is hump-shaped. For low values of $\gamma > \beta$, the union has a relatively small advantage in bargaining, and hence, union wages are only a little higher than competitive wages. As a result, the firm is more willing to hire a union worker with low productivity,

and competitive wages outside the union provide a relatively better option for workers with higher productivity. Then the set of unionized workers consists of workers with both low ability and low skill, which are small in measure given the distributions we use. As we let collective bargaining power increase relative to individual bargaining power, union workers are selected from the middle of the distribution where there is higher density. However, when γ is too high, only the very skilled are profitable hires. At the same time these workers would find it optimal to join the union since the wage benefits are high. As a result, the union contains workers with very high ability and high skill, which again have a small measure. Therefore, for each individual bargaining power, β , there is a unique collective bargaining power, γ , which takes a non-extreme value and maximizes the rate of unionization conditional on the skill distribution.

The highest rate of unionization given β may be far from 100%, depending on the value of individual bargaining power. In particular, for a fixed value of γ , the graph of the unionization rate as a function of γ shifts in the northwest direction as we decrease β : feasible unionization rates rise as the peak goes up and a smaller γ is required¹⁷ to obtain the same unionization rates. We choose β and γ such that in equilibrium, we obtain a peak unionization rate of 34.2%.

The bargaining parameters also have direct implications for the average union wage premium as well as the distribution of the wage premium across skill levels. To provide a better sense of our preferred bargaining parameters, we also compare the union wage premium implied by the model to those observed in the data in the next section. Somewhat surprisingly, the model-generated values are remarkably close to those observed in the data.

5 Results

The second panel in Table 1 summarizes the estimated parameters and the corresponding moments. Once we fix the calibrated parameters, we simultaneously choose the collective and individual bargaining powers along with standard deviations of the skill distribution and the skill price in the union to match aggregate union coverage, variance of wages and the estimates of wage compression and the standard deviation of s obtained under the assumption that union jobs are random. Since the identification is exact, we fit the targeted moments exactly. The estimated standard deviation for observed skill is 0.25 slightly lower than 0.29 as expected. The difference is attributable to the selection bias as discussed above. The standard deviation of unobserved ability component is 0.32. Similarly the estimate of the relative skill price in the union is 0.61, corresponding to a wage compression of 39% once selection is controlled for.

The implied bargaining powers for individuals and the union are 0.11 and 0.20. Estimates of

¹⁷See Figure 7 for an illustration.

workers' bargaining power are hard to come by in the literature. Cahuc, Postel-Vinay, and Robin (2006) provide estimates that vary between 0 and 0.3.¹⁸ The average bargaining power in our benchmark model is 0.14 in 1978 when we combine the unionized and non-unionized workers. This is well within the range of values provided by Cahuc, Postel-Vinay, and Robin (2006).

For the years 2005 - 2007, we simultaneously choose the skill prices in the two sectors, union and non-union, and the standard deviations of observed and unobserved skill components in order to match the estimated skill prices, wage compression and wage variance. We have two sets of estimates depending on the variance of wages we adopt. Scenario A, corresponds to the case where different components of wage variance rise proportionally. Our estimate for the rise in the skill premium in this case is 22.4%. The price of skill in the union sector is estimated to be 0.87, implying 29% wage compression after the selection into union jobs is controlled for. The composition of skills remain more or less constant in this scenario. In scenario B, when we let the variance of wages rise disproportionately higher, the estimates of parameters are similar to scenario A with the exception of σ_x which now rises to 0.39. This leads to a higher rate of deunionization in our model. We consider this scenario to yield an upper bound on deunionization effect of rising skill premium.

5.1 Union Membership and the Wage Distribution

We first discuss the implications of the model for the cross-sectional moments of wages and unionization for the years 1978 - 1980, starting with the union wage premium implied by our model in order to test our choice of bargaining parameters. Note that the union wage premium in the model for a worker with skill set (s, x) is:

$$w^n(s, x) - w^u(s) = \ln \phi_0 - (\psi - \phi_1)s - \ln C(\beta) - \psi x. \quad (19)$$

For a given value of ability x_o , the union premium attains its maximum at the lower skill threshold, $\underline{s}(x_o)$, and equals $-\ln C(\beta)$, which is 29.6% in our model for the years 1978 - 1980. The lowest observed union premium in the model is zero for the most skilled worker at the upper margin, $\bar{s}(x_o)$. The average realized wage premium for union workers is 14.8%. These figures are corrected for variations in ability that are not observable in the data. The observed union premium conditional only on s transcends both of these bounds. Due to selection, the average value of x conditional on being a union member will be lower than the unconditional mean for high enough values of observed skill s . This will generate an artificially high wage gain for low values of observed skill and artificially low wage gains, possibly negative, for highly skilled workers.

¹⁸This is not, however, the share of rent accrued by workers in their model. Due to on-the-job search, workers get 10 to 60% of total surplus, depending on their skill.

To be able to compare our results, we calculated the union wage premium for observable skill deciles by simulating the model and applying the same empirical procedures to model-generated data.¹⁹ To measure the union log-wage premium conditional on observed skill, we construct the skill index for all workers based on returns to education and experience in the non-union sector as described in the previous section. We then divide the unionized sample into quintiles with respect to the constructed skill index and calculate the difference between the mean wages of unionized and the corresponding non-unionized workers for each quintile. The first column of Table 2 shows the resulting wage difference in log terms for the years 1978 - 1980. The union premium is 0.38, 0.33, 0.23, 0.16 and -0.06 from the bottom to top quintile of skills.²⁰ The fact that less skilled workers have a larger gain from unionization is consistent with the wage compression observed within the union.

The fourth column shows the union premium calculated by applying the procedure above to the simulated data. The proximity of the model’s predictions to the data is striking. The model predicts decreasing gains to unionization with skill and negative gains for the most skilled workers when selection is not accounted for. We also ran an auxiliary regression of wages on observed skill and a dummy variable indicating union status. The measured union premium is 14.8%, which is close to the figures reported in the literature. This implies a selection bias of only 0.01%. That the selection bias is small is not surprising, because the ordinary estimates of the union premium are biased upward for low-skill workers, whereas they are biased downward for the high-skill workers, essentially offsetting each other. This is also consistent with the findings in Card (1996), who finds the union premium to be around 17% with or without selection. We next turn to the distribution of the union premium corrected for selection.

Elimination of the selection problems in the data is not straightforward. To get around the endogeneity problem, the literature has either relied on instruments for union participation or panel data with workers whose union status changed from one year to another. The work with instruments was mostly concentrated on obtaining an average union premium corrected for selection, which may not be so different from ordinary estimates in the case of a two-sided selection, since the biases at the two ends of the distribution offset each other. Using panel data, Card (1996) reports union wage effects that are corrected for selection and measurement errors by quintiles of predicted wages as presented here. He finds significant selection effects in the union wage premium, especially for the lowest and highest quintiles of the skill distribution. His preferred union wage effects for the years 1987-1988 are 0.28, 0.16, 0.18, 0.01 and 0.11 from the lowest to the top quintile with corresponding

¹⁹We have simulated an economy of 10K agents with 10K replications. The simulation errors are less than 0.01 for all reported statistics.

²⁰We correct for race, marital status and year effects in calculating these differences. The uncorrected raw wage differences are 0.46, 0.29, 0.19, 0.09 and -0.07 from the bottom to the top quintiles.

ordinary estimates of 0.37, 0.33, 0.21, 0.05 and -0.09 when selection is not controlled for. The ordinary estimates reported in this study are similar to the ones we calculated for the years 1978 - 1980. This is because the union wage premium in the United States remained constant from late 1970s through 1990s, reassuring our choice of constant bargaining parameters.

Using the simulated data, we calculated the quintiles of the true union wage premium corrected for selection.²¹ These are reported in the fifth column of Table 2. The union wage premium for the lowest quintile is 0.27, less than the 0.34 in the previous column due to correction for selection and close to the 0.28 reported in the third column for the years 1987 - 88. For the other quintiles, the simulated true wage premium is also close to those reported in his study, but by construction, the model-predicted wage premium is monotonically declining, whereas the figures in Card (1996) take a dip at the fourth quintile. We believe that the model's performance in terms of generating cross-sectional differences in the union wage premium reinforces our choice of parameter values for the model.

Next we turn to union participation rate implied by our model as a function of skill. Figure 8 shows the model-generated unionization rates for 1978 - 1980. Note that although we target the average unionization rate of 34.2%, the distribution is entirely determined by the selection process implied by our parameters, and the distribution of skills in the population. The model captures the inverse-U-shaped pattern observed in the data albeit not as forcefully. The curvature of the graph essentially depends on the variance of unobserved ability x in the population relative to the variance of the observed skill s . If the unobserved component had zero variation, then the union participation graph in Figure 3 would be a step function where the participation rate is 100% between two thresholds defined by Proposition 1. As the variance of x increases, the graph gets more disperse, eventually becoming flat at the limit. In section 5.4, we employ alternative parameters and analyze the sensitivity of our results to the curvature of the union participation graph.

Also note that our calibration of the bargaining parameters along with the choice of symmetric distributions for s and x necessarily imply that the union participation rate predicted by the model is symmetric. The participation rate in the data is skewed slightly to the left. The model can potentially generate skewed participation rates, by a slightly lower collective bargaining power in this case, but the implications of this for deunionization is negligible.

²¹The union premium as defined in equation (19) has a truncated normal distribution with mean $\ln \phi_0 - \ln C(\beta)$ and variance $\psi^2 \sigma_x^2 + (\psi - \phi_1)^2 \sigma_s^2$ and the points of truncation are zero and $-\ln C(\beta)$.

5.2 Rising Skill Premium and Deunionization

Overall, we consider the fit of the model to be quite well. Next, we re-calibrate our model using the skill prices and the skill composition²² in 2005-2007. We keep all of the parameters related to the search and matching framework including the bargaining powers constant. Overall the union wage premium has not changed much during the period we consider. This is also visible in the first three columns of Table 2. We therefore think that the relevant exercise for our purposes is one where relative bargaining powers of unions and individual workers are held constant.

We present the results in Table 3. The first two columns show the moments in the data. The third column summarizes the fit of our model for the years 1978 - 1980. In our conservative scenario of deunionization, shown in column 4, the aggregate union coverage declines by 6.5 percentage points to 27.7%. We take this to be a lower bound for the rate of deunionization implied by the rise in the skill prices. In Scenario B, which we take to constitute an upper bound on the contribution of changing skill prices to deunionization, the union coverage declines to 22.5%, a decline of 11.7 percentage points. We conclude from our benchmark results that the rising skill premium explains about a third to a half of the deunionization in the U.S.

Figure 9 compares the distribution of union participation rates by skill deciles before and after the rise in the skill premium. The first thing to note is that unionization rates for all skill deciles fall. This is mainly because the nature of the change in the skill premium pushes both the lowest and highest skilled workers out of the unions. Firms' hiring decisions play a crucial role for the decline in the unionization of low-skill workers, while skilled workers leave the union for the higher return to skill in the non-union sector. The reduction in the unionization rate, however, is reflected in all skill groups, since the ability, x , is not observed. This results in a more homogeneous set of union workers, partially offsetting the effect of the rising skill price within the union on the wage inequality among unionized workers. Second, recall that a part of the individual variation in skill is not reflected in union wages, since x is not priced in the union. This increases the effective wage compression within the union relative to the non-union sector, because both types of skills are valued equally (and highly in 2007) in the competitive sector.

The second feature to notice in Figure 9 is that the hump-shaped nature of union participation weakens just like in the data. This is in part a result of an increase in the underlying variance of x relative to s . The variation in wages as explained by our skill measures, education and experience, has risen relatively less than the variation in x . This produces a flattening out of the union participation curve.

²²We kept skill prices constant at their 1978 level to calculate the change in the distribution of skills. Alternatively, one could keep prices constant at their 2007 level and repeat the calculation. The results do not depend on the choice of the base year.

The model also predicts a decline in the steady-state rate of unemployment for 2007. The decrease in the proportion of workers with higher bargaining power increases the average return to a filled vacancy from the firm's point of view. This leads to the creation of additional vacancies raising the vacancy-unemployment ratio, θ , by 9 - 18%, and decreasing the unemployment rate by 3 basis points to approximately 5.7%.

Decomposing the Decline of Unions

The calibrated unionization rate in 2005 - 2007 is a result of the changing skill premium and the changing skill distribution. The changes in the skill distribution are associated with shifts in the experience composition of the labor force as well as changes in educational attainment. These alone would decrease the unionization rate if the skill distribution is getting more dispersed, for instance, if more workers are getting college degrees and the union participation rate for college graduates in 1978 is lower than average. To isolate the effects of price changes from compositional changes, we begin with a hypothetical calibration, in which we only raise the skill price in the competitive sector. The skill composition as well as the skill prices in the union sector are kept constant at their 1978 - 1980 levels. This by itself decreases the unionization rate to 26.5% in Scenario A and to 25.9% in Scenario B. This should not be taken to mean, however, that the true effect of the rising skill premium on deunionization is 8 percentage points, since the change in the skill composition could be a response to rising skill prices, for instance, the rising fraction of college graduates in response to the rising college premium.

Next we add the change in the composition of skills. This creates an additional 4% deunionization in Scenario B, but does not alter the deunionization in scenario A because the estimated skill composition in 2007 is very similar to 1978.

The benchmark calibration also allows the skill price in the union to rise. This could be interpreted as the union's response to the rising skill prices in the competitive sector. This attempt to retain union workers clearly counteracts the deunionization implied by rising skill premium only. The difference between columns 3 and 4 can be attributed to this. We conclude that the ease of wage compression in the union sector has curbed the effects of rising skill premium on unionization by 1-2 percentage points.

To illustrate the effect of each component on the distribution of union density by skill deciles, Figure 10 displays unionization rates for Scenario B. Rising skill price in the non-union sector shifts the entire union participation graph down, because the higher skill price raises the effective wage compression by the union not only with respect to observed skill but also with respect to ability conditional on skill. That the unionization rate has declined for all skill groups, but especially for the lower skilled groups, has been raised by [Gordon \(2001\)](#) as a concern as to the plausibility of a causal

effect running from the rising skill premium to deunionization, as formulated in [Acemoglu, Aghion, and Violante \(2001\)](#). Figure 10 shows that such a deunionization scenario is indeed consistent with a rising skill premium.

When we add the change in the skill composition, the graph of the union participation by skill slightly flattens and shifts further down. This is led by the rise in the variance of ability. When we adjust the skill prices in the union sector to their 2007 values, further expansion of the graph follows. The relative skill price ratio in the union increases from 0.61 to 0.70 between 1978 and 2007. The unionized workers in this case become more homogeneous in ability and this manifests itself as smaller differences in unionization rates across different skills.

Next, we analyze the composition effect of unions on overall wage inequality.

5.3 The Composition Effects of Deunionization on Wage Inequality

It has been argued that the decline of unions contributed to the rising wage inequality in the U.S. by changing the composition of the labor force. While these studies find the contribution of declining unions to wage inequality to be around 15-20%, they fail to consider the selection of workers into union jobs (see for instance [DiNardo, Fortin, and Lemieux \(1996\)](#) or [Freeman \(1993\)](#)). In this subsection, we use the estimated wage functions to gauge the effect of unions on wage inequality. In particular, we ask 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 the competitive sector is $\ln C(\beta) + \psi(s + x)$, the hypothetical variance without unions would simply equal $\psi^2(\sigma_s^2 + \sigma_x^2) = 0.166$. As the actual variance of log-wages in the model is 0.160 in 1978, the effect of unions on the variance of wages is -0.006, is 3.5% of total model variance.

To get a sense of the magnitude of this effect relative to the other figures in the literature, we replicate their statistics for our model 1978 economy. We first use the two sector framework suggested by [Freeman \(1993\)](#). Let $\Delta_w = E[\ln w|U] - E[\ln w|N]$ be the average union wage premium and $\Delta_v = Var[\ln w|U] - Var[\ln w|N]$ be the causal effect of unions on the variance of wages. Denote the aggregate rate of unionization by ρ_u . Simple algebra implies that the total impact of unions on wage inequality is

$$\rho_u \Delta_v + \rho_u(1 - \rho_u) \Delta_w^2,$$

where the first term is the decline in the variance due to wage compression among unionized workers, and the second term is the rise in the variance of wages between union and non-union sectors. Whether unions affect the variance positively or negatively depends on the size of the union wage premium relative to the wage compression.

When we carry out the calculation above we find that the impact of unions on variance is -0.069, about ten times larger than the true effect! Since we have earlier shown that the effect of selection on average union wage premium is small, the answer must be in the first component. With selection of union workers from the middle of the skill distribution $Var[\ln w|U]$ underestimates the hypothetical variance when union jobs are distributed randomly. Similarly the observed $Var[\ln w|N]$ is high not only because there is no wage compression in the non-union sector, but also because the non-union workers are selected from the tails of the skill distribution. This leads a big variance effect to be estimated when selection is ignored.

Card (2001) acknowledges that union participation varies greatly by skills and calculates the effect of unions on wage inequality taking into account that the effect of unions on average wages and the variance of wages may differ by skills. He uses a variant of the formula above extended to multiple skill levels where skill is measured by the deciles of workers' predicted wages in the non-union sector as done here²³. Using his method for our model 1978 economy, we find the impact of unions on variance to be -0.027 which coincides with his calculations for 1973-4. He also reports a version that attempts to correct for the selection bias in union wage premium (based on the difference in columns 2 and 3 of Table 2.). When we replicate this calculation we find -0.019. While this is an improvement, it is three times larger than the true effect of -0.006. The reason is that the suggested procedure corrects the selection bias in union wage premium, but it disregards the bias in the estimated variance effect Δ_v . This bias comes from the fact that the estimated non-union prices that are used to define skills and calculate the variance effect by skill are biased themselves.

It should also be noted that in these studies, the reported contribution of deunionization to rising wage inequality is computed as the difference between two years. Therefore, even though the statistics are biased in each year, the difference is closer to our findings here. For instance, Card (2001) estimates the effect of deunionization on variance of wages for men to be -0.008 when unionization rate declined from 35% in 1973 to 16% 1993. This is still slightly higher than our -0.006 for when we completely abandon unions but is an improvement over -0.019.

5.4 Matching the Union Participation Rate

The hump-shaped pattern in our benchmark analysis is not as strong as we observe in the data. In this subsection we analyze the sensitivity of our results to the variance of ability, which essentially determines the curvature of the graph of the union participation rate. We assumed that individual characteristics constitute 55% of the total variance of wages. In this section we will re-calibrate

²³Letting s denote an observed skill category, the formula for the effect of unions on the variance of wages is $Var[\rho_u(s)\Delta_w(s)] + 2Cov[E[\ln w|s, N], \rho_u(s)\Delta_w(s)] + E[\rho_u(s)\Delta_v(s)] + E[\rho_u(s)(1 - rho_u(s))(\Delta_w(s) + \delta_x(s))^2 - \delta_x(s)^2]$, where $\delta_x(s) = \psi E[x|s, U] - E[x|s, N]$ is the bias in the union wage premium for workers of skill s .

our 1978 economy assuming that this fraction is 30% and 40%.

Lowering the target wage variance has a direct effect on the estimated variance of ability. When we target 40% of the variance, σ_x is 0.24, lower than the 0.32 in our benchmark estimation. When the target is 30% of the variance in wages, σ_x decreases further to 0.16 (See Table 5). This results in a more curved union participation rate by skill as seen in Figure 11. While this improves the fit of the model, it does not have big impact on the effect of rising skill premium on deunionization. Table 6 shows that when we reduce the target variance, the deunionization implied by our model is 6 - 15% and 5 - 19%.

The estimated bargaining powers also increase slightly. The implied average union premium decreases to 11.4% and 8.4% respectively when we decrease the target wage variance to 40% and 30% of the total variance. Meanwhile, these changes do not affect the composition effect of unions on wage inequality. Our calculations indicate that if all union workers were paid according to the wage structure in the non-union sector, the variance of wages would increase by about 0.005 in both cases.

6 Conclusion

In this paper we investigated the role of the rising skill premium on the rate of unionization in and found that the rising skill premium explains about a third to a half of the deunionization in the U.S. in the last three decades.

The decline in the unionization rate has been suggested as one of the important determinants of the rise in wage inequality. The concurrence of the two events and cross-country evidence on the limited rise in wage inequality in more unionized economies is in line with this conjecture. We argue that when unions are organizations composed of agents who respond optimally to market conditions rather than well-established institutions that preserve their *status quo*, the causality could run the other way. We think that the decline of the unions is better interpreted not as a cause of the rise in wage inequality but a potential amplification mechanism.

We also estimate the impact of abandoning unions on the variance of wages. In our model economy, this leads to a negligible increase in the overall wage inequality. This is in sharp contrast with what earlier papers have reported. This is mainly because ignoring selection biases the estimates of both the union wage premium and the wage compression within the union. In particular, since union workers are selected from the middle of the skill distribution, the wage compression effect is exaggerated.

Although our model captures the main characteristics of unions, we have abstracted from a few potentially interesting extensions toward a more general theory of unions. First, the relatively

stable union wage structure for the time period we analyze led us to refrain from modeling the political process that pertains to wage determination within the union. Explaining why skill prices are compressed for union workers would contribute to our understanding of unions. Second, the production function is CRS, which prevents the availability of monopoly rents that can be extracted by the union. This could be particularly important in explaining the prevalence of unions in different industries or countries.

One crucial dimension that we have abstracted from in this study is the changing bargaining power of unions. For our calibration results, we have kept union bargaining power constant, but one might consider a size effect on collective bargaining power. If the decrease in the fraction of unionized workers is a detriment to their bargaining power, one would expect a larger decline in the rate of unionization than that predicted by our model. Alternatively, the presence of a similar size effect could be obtained as a natural consequence, for instance, in an economy where the marginal product of labor is decreasing, and the firm bargains with the union as if the unionized workers were the last to be hired as a block. Since the union bargains over the average product of unionized workers, a decline in the size of the union would bring the average product closer to the marginal product, creating an amplification mechanism for deunionization. Given that the union wage premium has in fact remained constant through 1980s and 1990s, when most of the deunionization has occurred, the unions must have traded members to keep the flow of rents constant. Since we do not address these potentially interesting features, we consider our result on deunionization to be conservative in general.

Our results indicate that an important fraction of deunionization in the United States still remains to be explored. One avenue that we think is promising is the change in the degree of competition in the U.S. economy. A rise in competition, particularly due to expanding international trade, could diminish the firm rents that can be exploited by unions, causing them to lose their *raison d'être*.

References

- Abowd, J. M. and H. S. Farber (1982). Job Queues and the Union Status of Workers. *Industrial and Labor Relations Review* 35(3), 354–367.
- Acemoglu, D., P. Aghion, and G. Violante (2001). Deunionization, Technical Change and Inequality. *Carnegie-Rochester Conference Series on Public Policy* 55(1), 229–264.
- Autor, D. H., L. F. Katz, and M. S. Kearney (2008). Trends in U.S. Wage Inequality: Revising the Revisionists. *Review of Economics and Statistics* 90(2), 300–323.

- Baldwin, R. E. (2003). *The Decline of US Labor Unions and the Role of Trade*. Peterson Institute for International Economics.
- Cahuc, P., F. Postel-Vinay, and J.-M. Robin (2006). Wage Bargaining with On-the-Job Search: Theory and Evidence. *Econometrica* 74(2), 323–364.
- Card, D. (1996). The Effect of Unions on the Structure of Wages: A Longitudinal Analysis. *Econometrica* 64(4), 957–79.
- Card, D. (1998). Falling Union Membership and Rising Wage Inequality: What’s the Connection? *NBER Working Papers* (W6520).
- Card, D. (2001). The Effect of Unions on Wage Inequality in the U.S. Labor Market. *Industrial and Labor Relations Review* 54(2), 296–315.
- DiNardo, J., N. Fortin, and T. Lemieux (1996). Labor Market Institutions and The Distribution of Wages, 1973–1992: A Semi-parametric Approach. *Econometrica* 64(5), 1001–1044.
- Farber, H. S. (1983). The Determination of the Union Status of Workers. *Econometrica* 51(5), 1417–1437.
- Farber, H. S. (1990). The Decline of Unionization in the United States: What Can Be Learned from Recent Experience? *Journal of Labor Economics* 8(1), 75–105.
- Farber, H. S. (2005). Union Membership in the United States: The Divergence between the Public and Private Sectors. *Princeton University Industrial Relations Section Working Paper*.
- Farber, H. S. and A. B. Krueger (1992). Union Membership in the United States: The Decline Continues. *NBER Working Paper* 4216.
- Farber, H. S. and B. Western (2000). Round Up the Usual Suspects: The Decline of Unions. *Princeton University Industrial Relations Section Working Paper*.
- Farber, H. S. and B. Western (2001). Ronald Reagan and the Politics of Declining Union Organization. *Princeton University Industrial Relations Section Working Paper*.
- Fortin, N. and T. Lemieux (1997). Institutional Changes and Wage Inequality: Is there a Linkage? *Journal of Economic Perspectives*, 75–96.
- Freeman, R. B. (1988). Contraction and Expansion: The Divergence of Private Sector and Public Sector Unionism in the United States. *Journal of Economic Perspectives* 2(2), 63–88.
- Freeman, R. B. (1993). *How Much Has De-Unionization Contributed to the Rise in Male Earnings Inequality?* Russell Sage Foundation.
- Gordon, R. J. (2001). Deunionization, Technical Change and Inequality: A comment. *Carnegie-Rochester Conference Series on Public Policy* 55, 265–273.

- Haider, S. J. (2001). Earnings Instability and Earnings Inequality of Males in the United States: 1967–1991. *Journal of Labor Economics* 19(4), 799 – 836.
- Howell, C. (1995). Turning to the State: Thatcherism and the Crisis of British Trade Unionism pp. 13-50. *New Political Science* 33-34, 13–50.
- Kahn, L. M. (2000). Wage Inequality, Collective Bargaining, and Relative Employment from 1985 to 1994: Evidence from Fifteen OECD Countries. *Review of Economics and Statistics* 82(4), 564–579.
- Lemieux, T. (1998). Estimating the Effects of Unions on Wage Inequality in a Panel Data Model with Comparative Advantage and Non-Random Selection. *Journal of Labor Economics* 16, 261–291.
- Lewis, G. H. (1986). *Union Relative Wage Effects: A Survey*. The University of Chicago Press.
- Machin, S. (2000). Union Decline in Britain. *British Journal of Industrial Relations* 38, 631–45.
- Machin, S. and J. V. Reenen (2007). Changes in Wage Inequality. *CEPR*.
- Mortensen, D. and C. A. Pissarides (1994). Job Creation and Job Destruction in the Theory of Unemployment. *Review of Economic Studies* 61, 397–415.
- Oswald, A. (1985). The Economic Theory of Trade Unions: An Introductory Survey. *Scandinavian Journal of Economics* 87, 160–93.
- Pissarides, C. A. (2000). *Equilibrium Unemployment Theory*. MIT Press, Cambridge.
- Pontusson, J. (2005). *Inequality and Prosperity: Social Europe Vs. Liberal America*. Cornell University Press.
- Shimer, R. (2005). The Cyclical Behavior of Equilibrium Unemployment and Vacancies. *American Economic Review* 95(1), 25–49.
- Woodcock, S. D. (2008). Wage differentials in the presence of unobserved worker, firm, and match heterogeneity. *Labour Economics* 15(4), 771–793.

DATA APPENDIX

The data are constructed from the Current Population Survey (CPS) May supplements for 1973-1981 and monthly CPS Outgoing Rotation Group (ORG) files for 1983 - 2007. We have used the annual extracts provided in the National Bureau of Economic Research CPS collection. Data on union membership are available starting with 1973; however, the survey question about whether

respondents' wage was covered under a collective agreement was only made available beginning in 1978. There are no union questions in the 1982 CPS.

The sample consists of male wage and salary workers in the private sector between the ages of 16 and 65. We use weekly earnings in our estimations. All top-coded values were replaced by a predicted mean, assuming that the underlying wage distribution is log-normal. We calculate real weekly earnings in 2007 dollars using the CPI index and drop all workers who earn less than \$110 a week, which corresponds to half the minimum wage for a 40-hour week. We measure education by the number of years of education completed and categorize education into 5 groups: those with less than 12, exactly 12, more than 12 but less than 16, exactly 16 and more than 16 years of education. Our experience measure is potential experience calculated as $\text{age} - \text{years of education} - 6$.

TABLES AND FIGURES

Table 1: Calibrated and Estimated Parameter Values

Parameters	Value	Targets	
<i>Calibrated Parameters (1978-1980)</i>			
Unemployment Benefit (ρ)	0.400	Shimer(2005)	
Matching Coefficient (η)	0.324	Avg. unemp. duration	3.09 months
Matching Exponent (α)	0.500	Normalization	
Separation rate (λ)	0.020	Unemployment rate	6.03
Vacancy Cost (κ)	3.188	$\theta = 1$	
Discount rate (δ)	$0.99^{1/3}$	Annual interest rate	4%
Price of Skill (1978 - 1980) ($\psi_{1978-80}$)	1.00	Normalization	
<i>Estimated Parameters</i>			
<i>1978 - 1980 Values</i>			
Union Bargaining Power (γ)	0.202	Union Coverage	34.2% (0.3 %)
Competitive Bargaining Power (β)	0.108	Union Coverage	34.2% (0.3%)
$\hat{\sigma}_{s,1978-80}$	0.252	Estimated standard deviation	0.294 (0.002)
$\hat{\sigma}_{x,1978-80}$	0.321	Variance of wages	0.160 (0.001)
$\hat{\phi}_{1978-80}$	0.612	Estimated Wage Compression	0.522 (0.019)
<i>2005 - 2007 Values: Scenario A</i>			
$\hat{\psi}_{2005-07}$	1.224	Estimated Skill Price	1.153 (0.005)
$\hat{\phi}_{2005-07}$	0.871	Estimated Wage Compression	0.645 (0.015)
$\hat{\sigma}_{s,2005-07}$	0.268	Estimated standard deviation	0.312 (0.001)
$\hat{\sigma}_{x,2005-07}$	0.321	Variance of wages	0.252 (0.001)
<i>2005 - 2007 Values: Scenario B</i>			
$\hat{\psi}_{2005-07}$	1.245	Estimated Skill Price	1.153 (0.005)
$\hat{\phi}_{2005-07}$	0.871	Estimated Wage Compression	0.645 (0.015)
$\hat{\sigma}_{s,2005-07}$	0.268	Estimated standard deviation	0.312 (0.001)
$\hat{\sigma}_{x,2005-07}$	0.391	Variance of wages	0.327 (0.001)

The estimation of parameters were done simultaneously for each year/scenario. Figures in parentheses are the standard errors used to weight the matched moments. See text for details.

Table 2: Results: Union Wage Premium

<i>Quintile</i>	Data^a			Model^b	
	1978 - 1980	1987 - 1988^c		1978 - 1980	
0 - 20%	0.38	0.37	0.28	0.34	0.27
20 - 40%	0.33	0.33	0.16	0.22	0.21
40 - 60%	0.23	0.21	0.18	0.15	0.15
60 - 80%	0.16	0.05	0.01	0.07	0.09
80 - 100%	-0.06	-0.09	0.11	-0.04	0.03
<i>Average</i>	0.18	0.17	0.17	0.15	0.15
Controlling for Selection	NO	NO	YES	NO	YES

a. log-wage differences between union and non-union workers, corrected for race, marital status and survey year effects. The sample consists of male, private wage and salary workers over the age of 16 in CPS May supplements (1973 - 1981) and monthly ORG files (1983-2007). Observations are stratified into deciles based on predicted wages in the non-union sector. *b.* Simulated data with a simulation standard error of less than 0.01. *c.* Taken from Table IV (p. 970) and Table VIII (p. 975) in Card (1996), respectively. These are for 1987 - 1988.

Table 3: Results: Model Deunionization

	Data		Model		
	1978	2007	1978	2007 A	2007 B
Unionization Rate	34.2%	10.8%	34.2%*	27.7%	22.5%
Standard Deviation of					
Log-Weekly Earnings ^a	0.54 (0.40)	0.68 (0.50)	0.40*	0.50	0.57
Union Workers	0.40	0.54	0.15	0.23	0.23
Non-union workers	0.60	0.69	0.48	0.58	0.64
Unemployment Rate	6.03%		6.03%*	5.76%	5.72%
Labor Market Tightness (θ)	-	-	1*	1.09	1.18

Table shows the changes in the model moments in response to the rising skill premium. *. Parameters are calibrated to match the 1978 data. ^a. The values in parentheses correspond to 55% of the wage variance, which is the model target for 1978.

Table 4: Decomposition of the Model Deunionization

Experiment	Scenario A	Scenario B
1978 - 1980 Economy	34.2%	34.2%
2005 - 2007 Economy with the new		
Non-union Skill Price	26.5%	25.9%
Non-union Skill Price and Skill Composition	26.1%	21.2%
Union and Non-union Skill Prices and Skill Composition	27.7%	22.5%

Table 5: Sensitivity Analysis: Parameters

<i>Target Wage Variance</i>	$\sigma_{x,1978}$	$\sigma_{s,1978}$	β	γ	$\phi_{1,1978}$
0.1604	0.321	0.252	0.108	0.202	0.612
0.1167	0.238	0.254	0.140	0.251	0.608
0.0877	0.160	0.260	0.186	0.317	0.622

The table shows the sensitivity of the estimated parameters to reducing the target wage variance from 55% of the total wage variance (Benchmark) to 40% and 30%.

Table 6: Sensitivity Analysis: Results

Target Wage Variance	Rate of Unionization			Average Union Wage Premium	The Effect of Unions on Wage Variance*	
	1978 - 1980	2007 A	2007 B			
0.1604	34.2%	27.7%	22.5%	14.8%	0.0056	3.5%**
0.1167	34.2%	28.2%	19.3%	11.4%	0.0053	4.5%**
0.0877	34.5%	29.2%	15.4%	8.4%	0.0046	5.2%**

The table shows the sensitivity of our main results to reducing the target wage variance from 55% of the total wage variance (Benchmark) to 40% and 30%. All parameters are re-estimated as reported in Table 5. * The rise in the variance of wages when all union workers are paid according to the wage schedule in the non-union sector. ** As percent of the total variance in the first column.

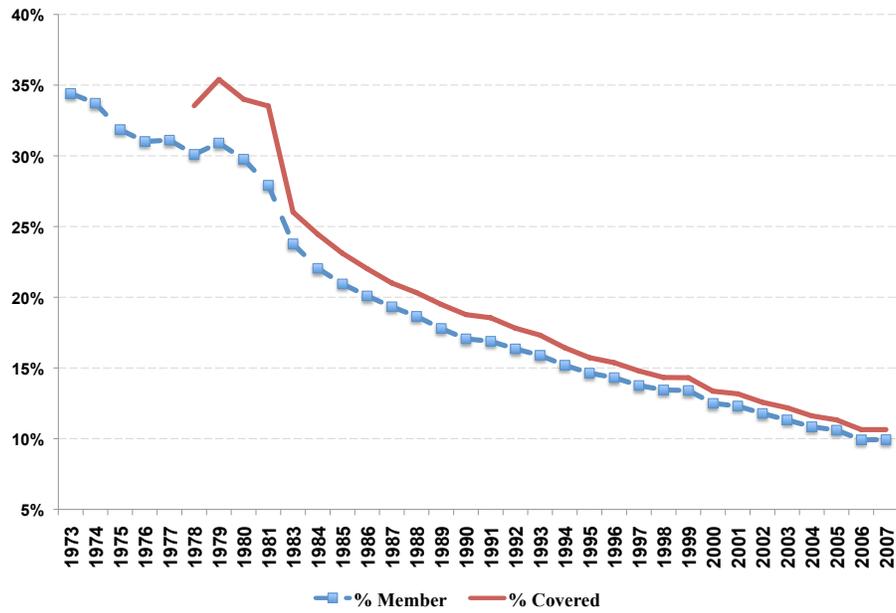


Figure 1: Rate of Unionization in the U.S. – The sample consists of male, private wage and salary workers over the age of 16 in CPS May supplements (1973 - 1981) and monthly ORG files (1983-2007). Membership is the percent of workers that belong to a union. Coverage is the percent of workers whose wages are determined by a collective agreement.

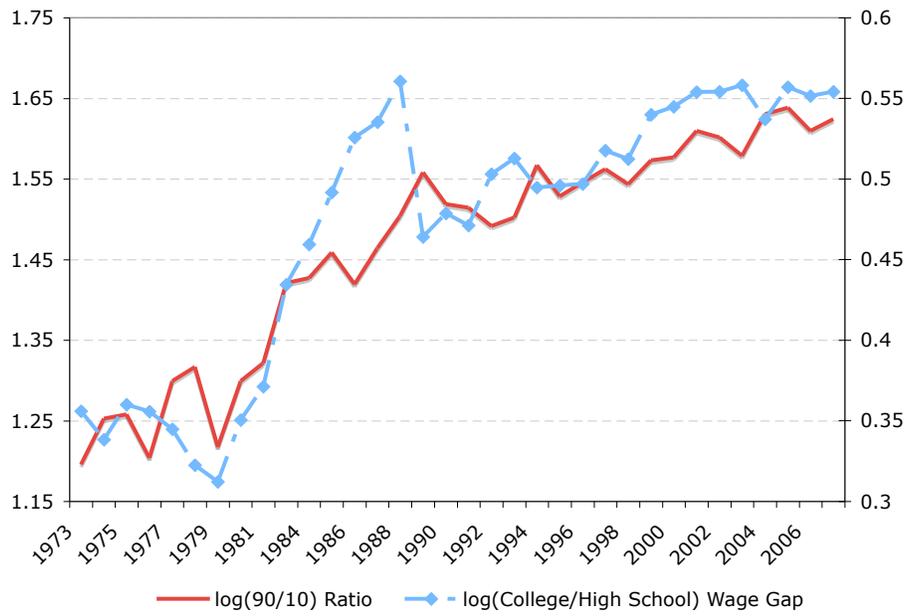


Figure 2: Rising Wage Inequality in the U.S. – The sample consists of male, private wage and salary workers over the age of 16 in CPS May supplements (1973 - 1981) and monthly ORG files (1983-2007).

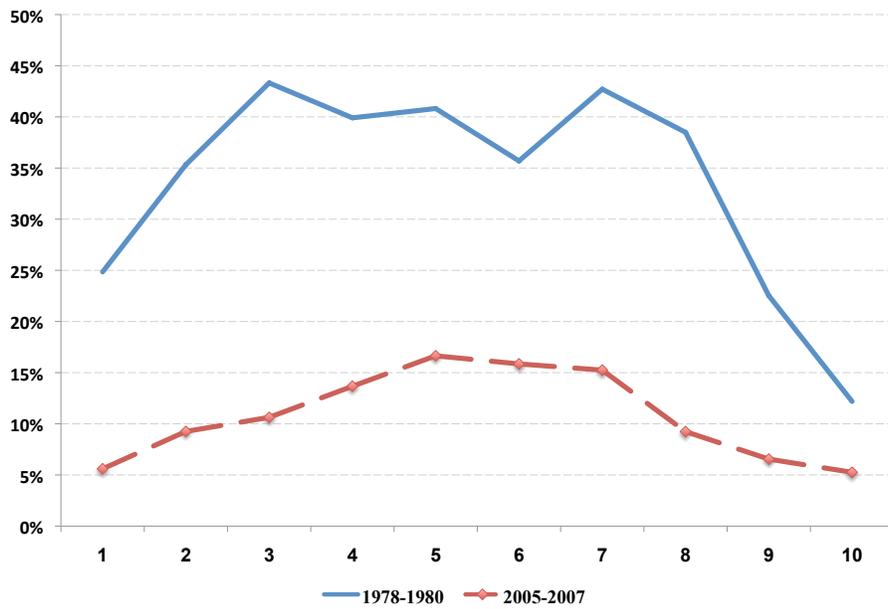
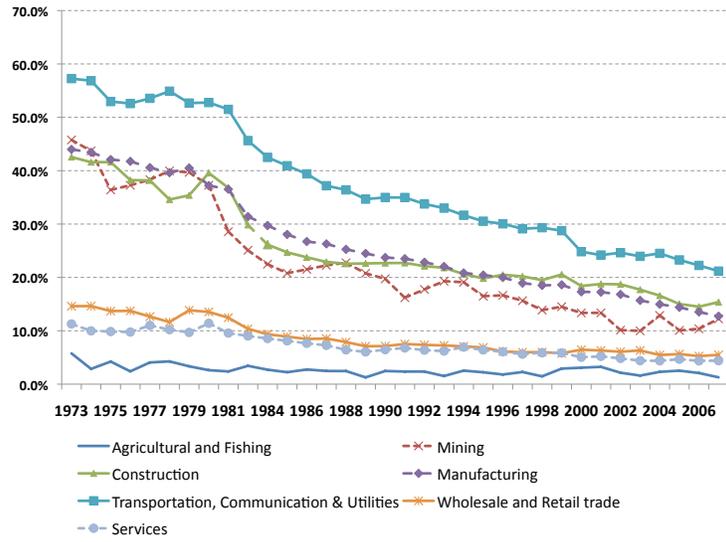
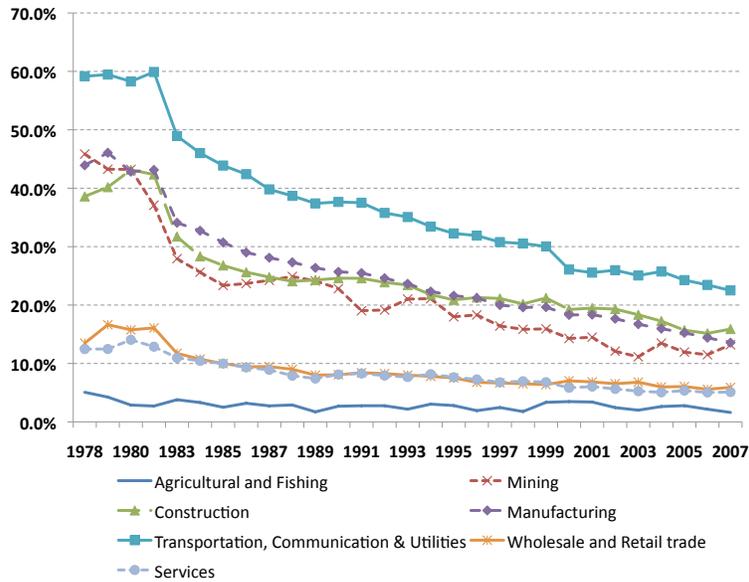


Figure 3: Union Coverage Density by Predicted Skill Deciles – The sample consists of male, private wage and salary workers over the age of 16 in CPS May supplements (1973 - 1981) and monthly ORG files (1983-2007). Observations are stratified into deciles based on predicted wages in the non-union sector. See section 4.2 for details.



(a) Union Membership



(b) Union Coverage

Figure 4: Union Membership and Coverage by Industry in the U.S. (1973-2007) – Percent of workers. The sample consists of male, private wage and salary workers over the age of 16 in CPS May supplements (1973 - 1981) and monthly ORG files (1983-2007). See the appendix for detailed industrial classifications.

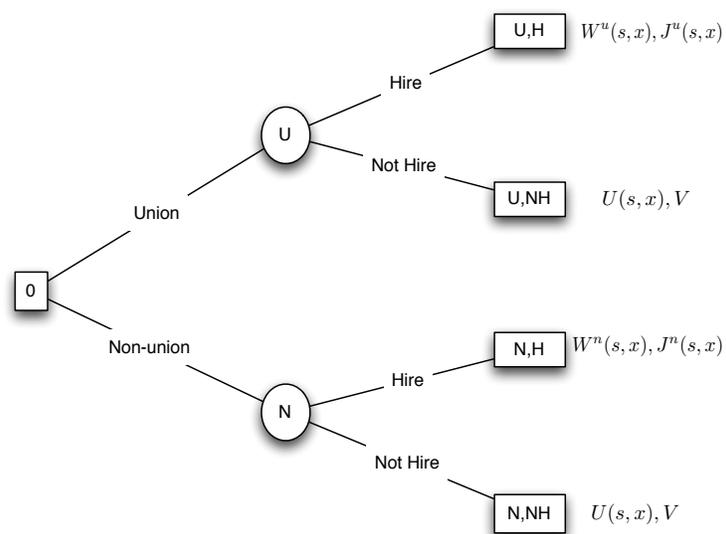
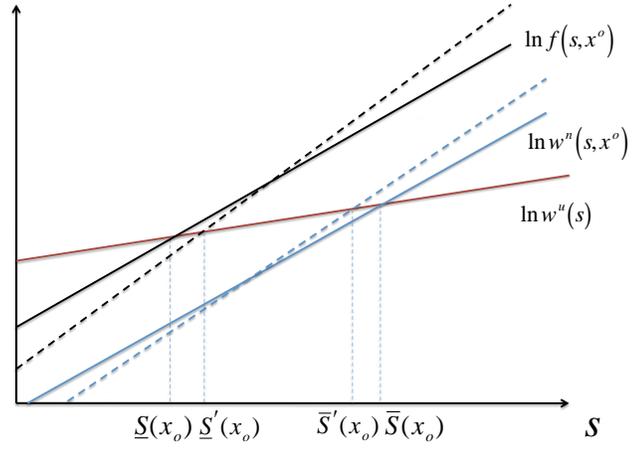
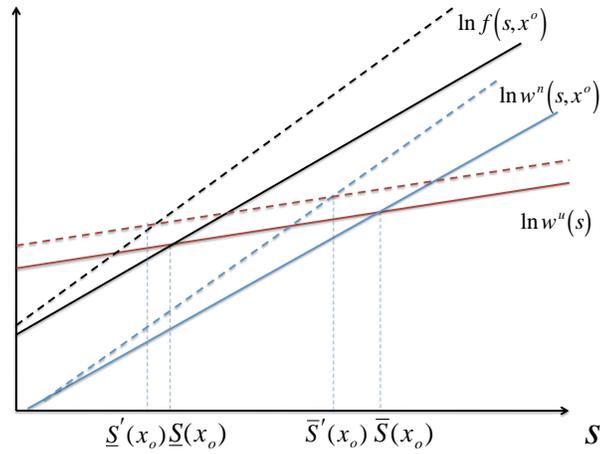


Figure 5: Game Tree and Payoffs for $\mathcal{G}(s, x)$



(a) Scenario I



(b) Scenario II

Figure 6: Rising Skill Premium and the Unionization Rate

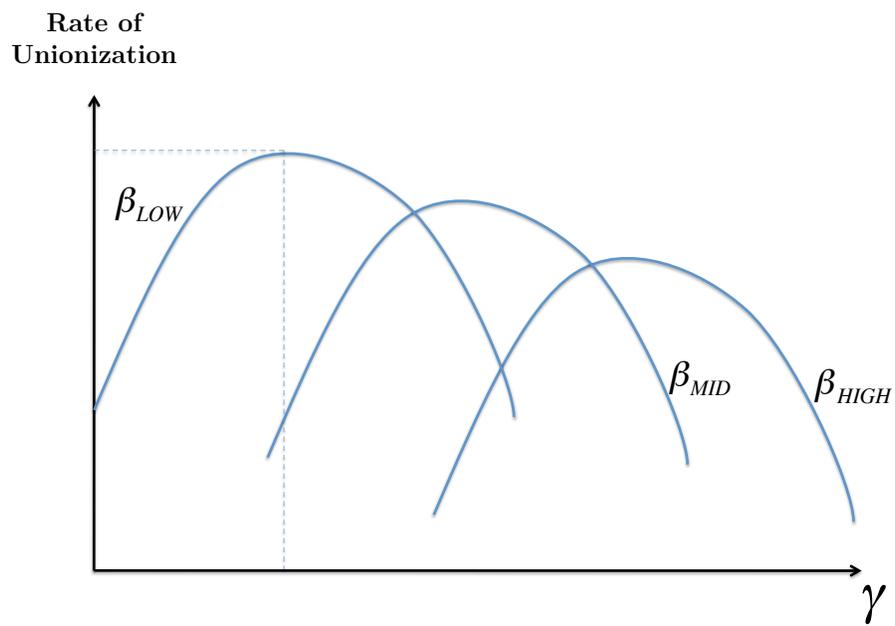


Figure 7: Rate of Unionization and Individual (β) and Collective (γ) Bargaining Power

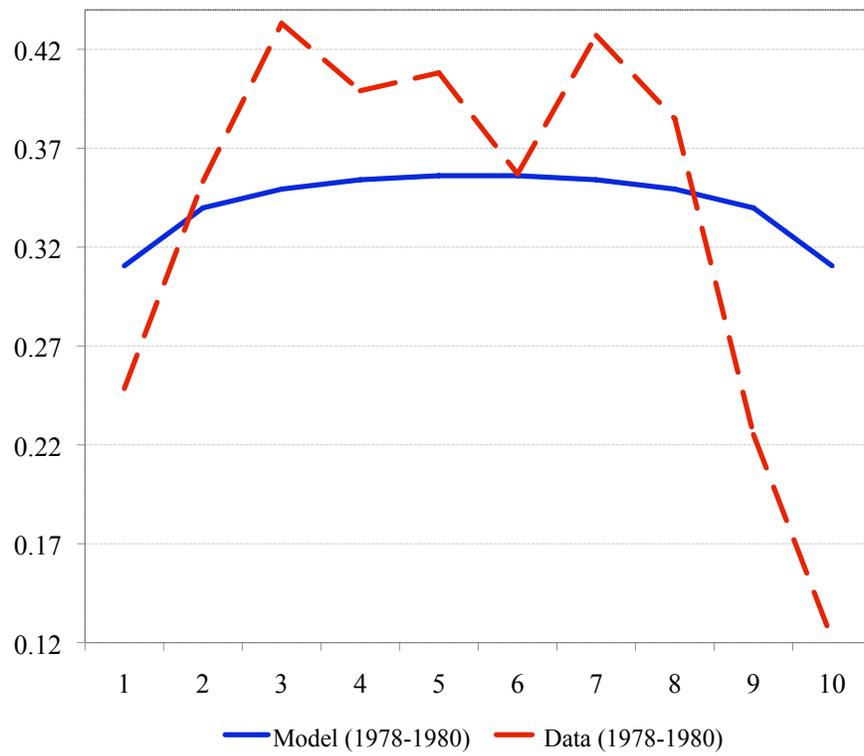


Figure 8: Model Unionization Rates by Skill Deciles: 1978 - 1980

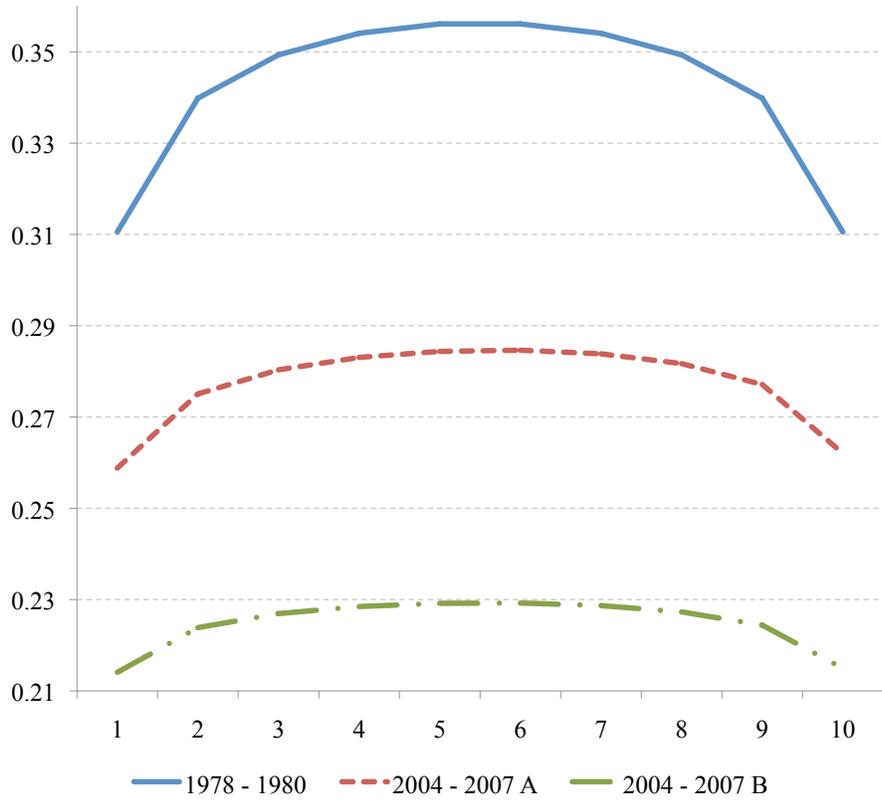


Figure 9: Model Deunionization by Skill Deciles: 1978 - 2007

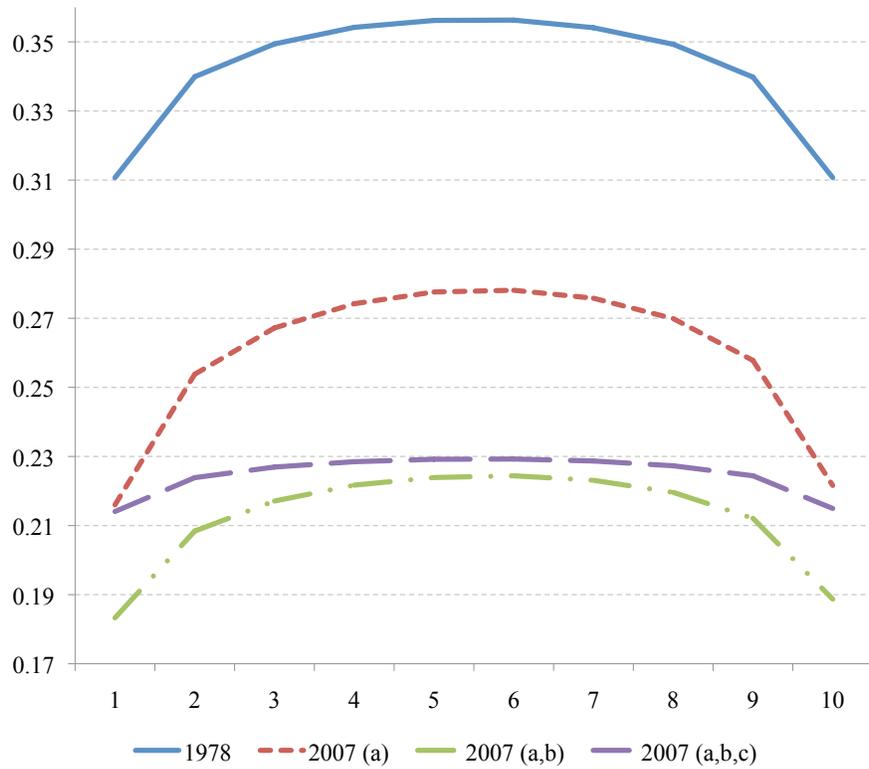


Figure 10: Decomposing the Model Deunionization: Scenario B (a) The price of skill in the non-union sector is raised to its 2007 value. (b) The skill composition was changed to its 2007 state. (c) The price of skill in the union sector is raised to its 2007 value.

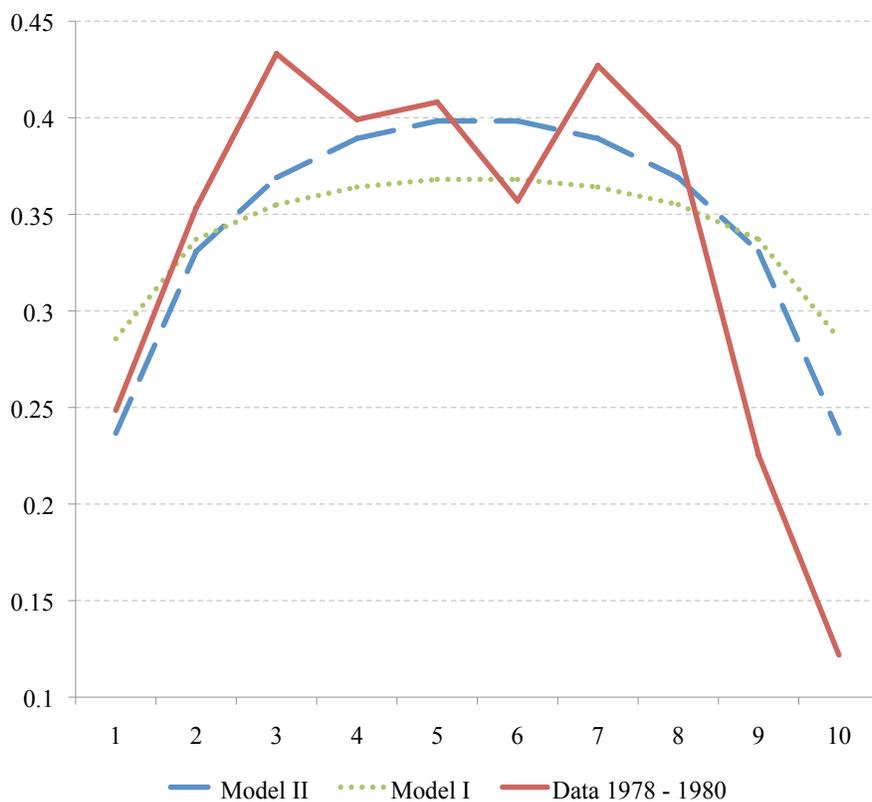


Figure 11: Sensitivity Analysis: Model Unionization Rate by Skill Deciles - 1978. Model I assumes that 40% of the total variance of wages can be attributed to individual characteristics. Model II assumes that this percentage is 30%. The benchmark model in Figure 8 assumes 55%.