# Wage Strikes in 1880s America:
# A Test of the War of Attrition Model

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## Abstract

By relating strike outcomes and durations to the value of the disputed wage change and to the cost to each side of continuing the strike, this paper tests the hypothesis that the war of attrition with asymmetric information model of strikes accurately describes the characteristics of strikes over wages in the United States in the early to middle part of the 1880s. That hypothesis is not rejected by linear, probit, or nonparametric kernel estimation. Specifically, variables that decrease a side's cost of striking or increase its opponent's cost are shown to increase its maximum holdout time, and vice versa, and strike duration increases with the value of the prize in dispute and with uncertainty about the outcome. Alternative game theoretic models of strikes – signaling and screening models, and models with ongoing negotiations – do not fit the data as well. We also explore why the strikes took the form of wars of attrition, and why later strikes did not. Our results have implications for modern union behavior in the face of globalization.

On Monday, June 23, 1884, nearly 1800 bituminous coal miners in Ohio's Hocking River Valley went on strike to protest a wage cut announced the previous Friday. Facing a depression, fierce competition from other mines, and slack summertime demand, the mine operators required the lower wage in order to maintain profitability (Rossel, 2002 p.5). The feeling among the union miners, though, was that the operators intended to deprive them of their just wages, to control the labor market, and to "crush them out" (Lozier, 1963 p.56). For their part, the owners "expected the miners would resist the wage cut demand but did not think they could hold out long … . [F]or the first two weeks the operators did nothing but wait for union submission" (Lozier, 1963 p.58). In fact, the strike lasted nearly ten months. On March 18, 1885, the miners accepted the operators' wage terms and returned to work. That costly strike, typical in many ways of the great wave of strikes in the United States in the 1880s, is difficult to explain with a model based on one-sided incomplete information, such as signaling or screening models. Instead, the two sides' "mutual hostility" and "inability to understand the needs and motives of each other" (Lozier, 1963 p.108) are suggestive of bilateral asymmetric information, and in particular of the war of attrition.

In the war of attrition (Maynard Smith, 1974), two sides compete for an indivisible prize. They keep fighting, each trying to gauge how much longer its foe can endure, until one side finally gives up. The victor obtains the prize; the loser has nothing to show for its costs. The asymmetric information version of the war of attrition, where neither side knows the exact value of its opponent's costs, is a possible explanation of how labor strikes unfold. This paper tests whether the predictions of the war of attrition

model are consistent with the characteristics of strikes over wages in the United States in the 1880s.

The *Third Annual Report of the Commissioner of Labor* (1888) contains detailed data on those strikes. The *Third Report* includes strikes over a variety of causes — the advantage of looking at wage strikes is that the value of the prize in dispute is easy to quantify. Card and Olson (1995) have previously analyzed the strikes of the 1880s using a war of attrition model. However, their aim is not to test the validity of the model. Instead, they assume that it holds and look for a relationship between the probability that workers win a strike and the wage increase conditional on success.[1] Here, by relating strike outcomes and durations to the value of the disputed wage change and to determinants of the cost to each side of continuing the strike, we fail to reject the null hypothesis that the war of attrition model is correct. Specifically, the data show that an increase in variables that lower a side's cost of striking (the wage available in alternative employment and warm weather for workers, the capital labor ratio for firms) has a positive, statistically significant effect on that side's maximum holdout time. Conversely, raising the value of variables that increase the cost of striking (the foregone wage and the local unemployment rate for workers, the value of yearly output and the fraction of employees out on strike for firms) results in a statistically significant drop in the holdout time. Also, the expected duration of a strike increases with the value of the prize in dispute. The duration also rises when the predicted probability of success for the workers is close to one half – that is, strikes where one side has a clear advantage end more

[1] Because Card and Olson (1995) find that predictors of strike success are correlated with the post-strike wage change, and because each side's holdout time depends on that projected wage change, Card and Olson's (1995) estimates may suffer from omitted variable bias. They also include strike duration, an endogenous variable, as a regressor.

quickly. Alternative models of strikes based on signaling and screening do not fit the data as well, and neither do models that allow for continued bargaining during the strike.

The war of attrition, relative even to other types of strikes, is a very costly way to settle labor disputes. Why, then, did the wage strikes of the 1880s take that form? Card and Olson (1995) offer one possible explanation, that the actual issue in dispute in many of the strikes was whether or not workers had the right to bargain collectively; that issue could not be compromised. The data suggest that that explanation is incorrect. Instead, we identify three factors leading to wars of attrition: the two sides did not trust each other to honor agreements, impartial arbitration was unavailable, and the surplus to be divided was small. Over time, changes in macroeconomic conditions and product market structures, combined with a growing recognition of the high costs of war-of-attrition strikes, led to an increase in negotiation and compromise.

In the conclusion, we explore how the factors that led to wars of attrition in the 1880s may arise again in an era of globalization.

## Strikes in the 1880s

The 1860s saw the beginnings of national labor organizations in the United States, spurred by the price fluctuations of the Civil War and by the downward pressure on wages as railroads opened up businesses to increased competition. The long depression from 1873 to 1879 and a series of failed railroad strikes in 1877, however, dealt serious blows to the young labor movement. The great rise of organized labor, and especially of the Knights of Labor, came in the 1880s. The Knights' membership grew from 20,000 in

1879 to 700,000 in 1886. The total membership of labor organizations in the later year was close to one million. (Commons et al., 1926)

With the rise in labor organization membership came a rise in strike activity. In 1886 alone the United States Bureau of Labor reported almost 2500 strikes (Commissioner of Labor, 1888). The most common cause of the strikes was disputes over wages. Strikes are of particular interest to economists because they are wasteful. During a strike, firms lose profits and workers lose wages. Both sides would have been better off if their final agreement had been implemented without a strike. During the late nineteenth century, the number of strikes was growing, as Figure 1 shows. That growth continued into the twentieth century: in 1915 there were over 3500 strikes (Griffin, 1939). According to estimates by the Commissioner of Labor (1888, 1896), the cost of these strikes between 1881 and 1894 was over $178 million in lost output and wages (roughly 3 billion in 2004 dollars), or $12.7 million annually (230 million 2004 dollars). (See Table 1.) Strikes became a more and more source of inefficiency over the period.

The Commissioner of Labor classified the strikes as successes, failures, or compromises. As defined by Griffin (1939), a "failed" strike is one in which the union largely failed to achieve its aims. A "successful" strike is one in which the union "gained the major part of their expressed demands." Finally, a "compromise" outcome involves "an intermediate [outcome] in which neither side has been completely victorious."[2] Relatively few strikes ended in compromise during this period, as shown in Figure 2. In

[2] Griffin (1939) cautions that "[t]he limitations inherent in such a classification must be carefully borne in mind." However, Card and Olson (1995), who discuss the rarity of compromises in the 1880s, argue that "government statisticians and academics at the turn of the century made extensive use of the classification. These analysts evidently viewed the distinction between successful and failed [and compromised] strikes as a natural and empirically useful taxonomy."

eleven of the nineteen years from 1880 to 1898, the proportion of compromise outcomes is below ten percent, and the average between 1881 and 1885 is less than nine percent (Edwards, 1981 p.42). For the most part, then, strikes in this period had the "winner-take-all" characteristic that Card and Olson (1995) describe.

In terms of general economic conditions (Figure 3), the years 1880 to 1898 were ones of relatively high unemployment, general deflation, and relatively slow money wage growth (roughly half of the real wage growth during this period was due to falling consumer prices). Worker bargaining power was limited.[3] That weakness is indicated by relatively low union densities and strike activity for most of the period (Figure 4).

## The War of Attrition

Maynard Smith (1974) introduced the war of attrition as a model of fights between animals over territory. Two players are fighting for a prize, which can go to only one of them. Each player bears a constant cost per unit of time spent fighting. Every period, each player must decide whether to give up and let his opponent have the prize or to keep fighting in the hopes that his opponent will soon surrender. The value of the prize, which may be different for the two players, is a random variable observable by the player himself but not by his opponent. Alternatively, each side's value may be commonly known, but a player's cost of fighting is known only to himself. For the purposes of theory, we may assume without loss of generality that only the costs are random: the relevant number is the ratio of the prize value to the fighting cost.

[3] According to Kennan (1986) cross-country studies have found strike activity to be positively related to the inflation rate; thus deflation will tend to create a more docile labor force.

The war of attrition (also known as a second-price all-pay auction) has been used to model not only biological phenomena but also economic situations as diverse as market exit (Fudenberg and Tirole, 1986), the provision of public goods (Bac, 1996a and 1996b; Bilodeau and Slivinski, 1996), and marriage duration (Allen, 1994). Kennan and Wilson (1989) explain how the model can be used to explain labor strikes. In the case of wage strikes, the two players are the firm and the striking workers, and they fight over the difference between the wage offered by the firm and the wage demanded by the workers. Each side is imperfectly informed about the cost to the other side of allowing the strike to continue. For example, the workers may not know precisely what the profits of the firm are in the absence of a strike, and thus may be unaware of what level of income the owners of the firm are forgoing while the strike continues. The firm, on the other hand, may not know to what extent the workers have alternative sources of income.

Following Nalebuff and Riley (1985), let $V_f$ and $V_w$ be the prize values to the firm and to the workers, respectively; the prize values do not vary over time. Let $t_f$ and $t_w$ be the costs per unit time of continuing the strike for the two sides. Then $v_f \equiv V_f / t_f$ and $v_w \equiv V_w / t_w$ are the prize values normalized to be measured in units of the cost of time. The values $v_f$ and $v_w$ are random variables that are not observed by the other side. Let their probability distributions, which are commonly known, be denoted $P_f$ and $P_w$. A player's strategy is given by a *concession function* mapping from normalized prize values to maximum holdout times; the player will allow the strike to continue until either his opponent yields or he reaches his maximum holdout time. An equilibrium for this game is a pair of concession functions $(T_f(\cdot), T_w(\cdot))$ such that $T_f(v_f)$ maximizes the firm's expected utility given $v_f$, $T_w(\cdot)$, and $P_w$, and vice versa.

Under some conditions on the distribution functions, Nalebuff and Riley (1985) show that the war of attrition has a continuum of strict Nash equilibria. However, they also show that the continuum is reduced to a unique equilibrium if there is a positive probability that either side will not ever yield.[4] Since one percent (11 of 1108) of the strikes in the sample used here never end (in the sense that all of the striking workers were permanently replaced), it seems reasonable to assume that the probability that a side will never yield is positive, and that thus each strike has a unique equilibrium. Each side's maximum holdout time, then, is a function of its own costs and any information it has about the other side's distribution of normalized prize values. Formally,

$$T_i = \Pi_i(X_i, X_j, X_V) + \varepsilon_i, \qquad \textbf{(1)}$$

where $T_i$ is side *i*'s maximum holdout time, $X_i$ is a vector made up of the publicly observable determinants of side *i*'s fighting cost, $X_j$ is a vector of the publicly observable determinants of side *i*'s opponent's fighting cost, $X_V$ is a vector of publicly observable determinants of the prize value, and $\varepsilon_i$ is an unobserved, mean zero random variable that corresponds to side *i*'s private information, for $i, j \in \{f, w\}$, $i \neq j$. For the purposes of estimation, we assume that $\Pi_f$ and $\Pi_w$ are linear, so that

$$T_f = X_f F_f + X_w W_f + X_V V_f + \varepsilon_f \text{, and} \qquad \textbf{(2a)}$$

$$T_w = X_w W_w + X_f F_w + X_V V_w + \varepsilon_w. \qquad \textbf{(2b)}$$

[4] Amann and Leininger (1996) offer a different reason to believe that a unique equilibrium will be played. They characterize that equilibrium as the limit of the equilibria of a class of games that converge to the war of attrition.

For the case of a symmetric war of attrition, where $P_f = P_w$, Fudenberg and Tirole (1986) demonstrate that an increase in the prize value relative to fighting costs increases the maximum holdout time. Card and Olson (1995) extend that result to a class of asymmetric distribution functions: a downward shift in the distribution of one player's costs increases the expectation of his maximum holdout time and decreases the expectation of his opponent's. An upward shift in the distribution of the player's opponent's cost has the same effect.[5] We test the model by checking whether or not changes in publicly observed determinants of fighting cost move holdout times in the predicted direction: Any variable that increases a side's own cost or decreases its opponent's cost should have a negative coefficient in Equations 2a and 2b; a variable that decreases a side's own cost or increases its opponent's cost should have a positive sign.

## Qualitative Evidence for the War of Attrition Model

Qualitative evidence on the strategies followed by workers and firms in 1880s labor disputes supports the war of attrition model. Each side had to carefully assess its own strength relative to that of its opponent. In giving advice to potential strikers, W.Z. Foster (1926 pp.32-33) emphasizes the need to "make a careful survey of … the strength and disposition of the enemy's forces" in order to "gauge the strength of the enemy, to know … whether he is being seriously weakened or not." He also says that

> … [t]he most powerful of all the weapons employed by the capitalists in ordinary strikes is that of hunger. They seek to starve the

[5] Note that in a complete information war of attrition, the effect is reversed: an increase in one side's costs increases the probability that it wins the prize. See Maynard Smith (1974).

> workers, their women and their children; to shut off their supply of life necessities until their courage is broken and they come back to work upon the employers' terms, defeated. (Foster, 1926 p.57)

Striking workers often made explicit plans to provide themselves with income, food, and other necessities during a labor action. Planning for the 1881 textile workers strike in Fall River, Massachusetts involved "arrang[ing] means for sustenance," "pledges of aid from outside organizations," and "contracts . . . placed for supplying the operatives with coal, flour, and groceries during the strike" (*New York Times* 1881a, 1881b, 1881e).

Sociologist E.T. Hiller, writing in 1928, offers even stronger support for the idea of strikes as wars of attrition:

> In its most characteristic form the strike is a test of economic endurance — a process of attrition — in which the outcome is determined by the relative resources of the contestants. The one who is able to hold out longer is the victor. Therefore each party watches closely every move and every sign of weakening which may serve as an indication of the strength and endurance of his opponent … .
>
> Settlement by exhaustion implies that one or both parties are exhausted or prefer to surrender because defeat seems imminent. Each estimates the limits of his resources as compared with those of his opponent and gauges his own inevitable losses against possible gains. (Hiller, 1928 pp.195, 198)

Summer (1914) says that a strike "simply aims to see who can stand it the longest" (quoted in Hiller, 1928 p.193). Newspaper accounts from the 1880s paint a similar picture. To choose one example, as a strike by glassblowers in Pittsburgh began in 1883, the *New York Times* (1883d) reported that "a manufacturer said the question was now one of endurance, and he thought the best filled pocket-books would win in the end. The men say they are prepared to hold out until the manufacturers give in."

In a war of attrition, not just a side's own ability to endure matters, but also its estimate of the other side's endurance. Thus, workers try to convince the firm that they suffer little from the strike and that they can hold out indefinitely, so that the firm should surrender right away rather than hold out longer and then lose anyway. The firms, of course, try to convince the workers of the opposite. That pattern shows up in the newspaper as well. An official at an iron mill in Chicago said of an imminent strike in 1883, "Of course we are in better shape to stand a two months' shut down than the men are. … A few months of enforced idleness is generally something of a severe trial to the bulk of ordinary workmen" (*New York Times* 1883b). That same year, the manager of a Western Union office in St. Louis claimed to be experiencing no difficulties from a telegraphers' strike: "everything is going along here smoothly and well" (*New York Times* 1883c). Also in 1883, railroad coal miners struck in Pittsburgh. Coal company owners "profess to be indifferent to how long the strike lasts." One claimed that, "As good luck would have it, our contracts were not closed before the present agitation started, and the strike now finds us prepared to shut up the mines and take things easy until next Fall. … So let the miners go it; they can get all the strike they want." For their

part, the miners said of the strike, "Everything is going on swimmingly," and insisted "that the operators' statements are the veriest buncombe, and that they are exceedingly anxious that work should be continued" (*New York Times* 1883a).

Measures taken by workers and firms to influence the other side's cost of holding out are also consistent with the war of attrition. Workers might time strikes or adjust tactics to inflict maximum damage to firms in order to reduce their ability to take a long strike. One example of this tactic was the planning for the aforementioned Fall River strike. The *New York Times* (1881d) reported in February that ". . . the strike will not take place this month, and possibly not before April 1, the operatives hoping that by that time goods may have advanced [in price] . . . when, if there were any sign of permanency in prices, manufacturers would probably advance wages voluntarily." A Newark, New Jersey strike of construction workers in March 1881 provides another example. "Building is very brisk at present," one report stated, "so that the strike comes at an inopportune time for the bosses" (*New York Times* 1881f). New York City streetcar drivers employed this strategy in April 1881; they believed there was "… no doubt that [the strike] would compel the company to come to terms. The present time is regarded … as the best in which to make the attempt to cripple the company, because the spring business is at its height" (*New York Times* 1881h). A mine operator in Ohio "would not have dared to let my men know of it" if he received a large order, for fear that the miners would see a good chance to strike (Bemis, 1888 p.34). Strategies for increasing costs borne by firms include attempts to prevent replacement workers from taking strikers' jobs, secondary strikes by workers in other occupations in response to employer provocations, and organized boycotts of struck firms. At an 1881 strike of Cincinnati

newspaper printers, for example, sympathetic members of other trade unions agreed to "work to lessen the advertising and subscription patronage" of the paper involved (*New York Times* 1881c). During the Fall River strike, the *Times* (1881g) reported that the strike organizers "are making determined efforts to prevent the places of the striking spinners … from being filled," that "a watch is kept to prevent help being brought to the mill," and that "notices have been sent to every city where print cloths are manufactured … warning the operatives to stay away from the city."

Contemporary accounts also emphasize a general unwillingness to compromise on the part of both workers and firms. The official at the iron mill in Chicago was asked, "Would it not be possible to effect a compromise?," and answered, "No. The terms are: The scale price or nothing. The men are bound by cast-iron laws and must follow the instructions from head-quarters, so that there is nothing left for the employers to do but to either accept or decline. We decline." Another official said, "There have been no negotiations between the workmen and myself" (*New York Times* 1883b). In St. Louis, "There is no talk of compromise here on either side" (*New York Times* 1883c). The Pittsburgh glassblowers "rejected the proposed reduction [in wages], and the manufacturers refused to offer any other terms. The strike will, therefore, go on indefinitely" (*New York Times* 1883d).

The rarity of compromises provides further evidence for the war of attrition model. In that model, the parties cannot negotiate during the strike. A fuller model might allow the sides the option to communicate. However, neither contestant would offer a compromise if such an action signaled doubts about its ability to endure a lengthy strike. Hiller (1928, p.197) says that "[a]n offer by one party to settle or to make

concessions is interpreted by the other as a sign of weakness." As Cross (1969 p.93) puts it,

> … if one of the negotiators or an ally of his were to suggest an "arbitrated" outcome, that party thereby would run the risk of appearing very anxious to reach agreement, and even willing to make large concessions to do so. The likely result would be a hardening of the other party's position rather than an early settlement. It is by nature impossible to make a "move" during the bargaining process without having it react upon the expectations of the opponent.

That effect is also illustrated in the newspaper. During a strike by brass workers at Peck Brothers' foundry in New Haven in 1886, "John J. Caville, from the Knights of Labor, called on A.T. Foster, President of the Manufacturers' Association, to talk about terms of a compromise." Mr. Foster replied that "[t]he only thing Peck Brothers could consent to … was for the workmen to go back to their work unconditionally," and that "no compromise whatever could be accepted." Later that same day, the strikers surrendered, and Mr. Caville "issued the order for the men to return to work" (*New York Times* 1886b). At a strike by cigar makers in New York City in 1886, workers tried to avoid the bad signal sent by an offer to compromise, as shown by the reaction of the International Union Strike Committee to the news that two other unions involved had "waited on the Executive Committee of the United Cigar Manufacturers' Association in the afternoon

and declared their readiness to enter into negotiations with a view to a compromise." The International Union Strike Committee

> … condemned the action of the Progressive and Central Labor Unions as treacherous to the cause of labor and especially to the cigar makers, and recorded an emphatic protest against any agreement entered into by them. Finally the old scale of prices was insisted upon and any compromise leading to a reduction of wages was repudiated. (*New York Times* 1886a)

During the 1881 Fall River textile workers' strike,

> … the spinners . . . took umbrage . . . . at an item which appeared in the Fall River *Herald*, which claims to be an organ of the operatives, stating that the union would compromise the difficulty if wages were advanced 5 percent . . . Secretary Howard [of the spinners' union] said the statement was made without his authority, and promises to secure its denial (*New York Times* 1881d).

These strategies – careful assessment of own and opponents' ability to endure a long strike; attempts to influence the beliefs of the other side regarding one's own ability to endure; efforts to shift the relative costs of striking in one's own favor; and an unwillingness to compromise – are quite consistent with the war of attrition.

## Data

The data, which are summarized in Tables 2 and 3, come from three sources: the *Third Annual Report of the Commissioner of Labor* (1888) provided by Janet Currie and Joseph Ferrie, the state-level samples of the 1880 *Census of Manufactures* constructed by Jeremy Atack and Fred Bateman, and the sample of the 1880 *Census of Population* from the Integrated Public Use Microdata Series at the University of Minnesota.

The *Third Report* represents the attempt of the Bureau of Labor to gather information on every strike in the United States from 1881 to 1886 (Edwards, 1981). Currie and Ferrie's data set includes strikes from thirteen states. Those states, drawn from the Midwest, New England, and the Middle Atlantic region, were selected because almost 90% of the strikes recorded by the Bureau of Labor between 1881 and 1894 occurred in them (Currie and Ferrie, 2000).[6] Each observation includes data on the date, location, cause, and duration of the strike; the industry of the affected firm; the pre- and post-strike average daily wages; the total number of employees, male and female; the fraction of employees striking; whether or not replacement workers were used; and whether or not the strike succeeded, among other variables. Note that the use of replacement workers does not imply that the workers lost the strike. Often, the replacements were imperfect substitutes for the striking workers, and were intended to be used only temporarily. Ehrlich (1974 p.533) reports that firms

> generally found that they could ill afford the luxury of employing

[6] The *Tenth Annual Report of the Commissioner of Labor* (1896) includes data on strikes from 1887 to 1894. Unlike the *Third Report*, however, it does not include observations of pre- and post-strike employment or wages, so it cannot be used to estimate the model in this paper.

> unskilled transient labor. The owner of a Scotdale, Pennsylvania iron mill evidently learned this lesson the hard way. After introducing a hastily assembled group of unskilled scabs into the plant, wastage and equipment damage evidently rose to such proportions that Scotdale was regularly referred to as "Scrapdale" ….

In the 1884 Hocking Valley coal strike, the productivity of strikebreakers was less than half the normal level, and after accounting for the costs of "recruiting, transporting, guarding and training the strikebreakers," the owners made no profit at all (Lozier, 1963 p.62).

Although the Bureau of Labor went to great effort to document every strike, it apparently did not succeed. Bailey (1991) reports that the *Third Report* and the later *Tenth Annual Report of the Commissioner of Labor* (1896) list only half of the strikes in Terre Haute, Indiana that were mentioned in local newspapers from January 1, 1881 to June 30, 1894.[7] He finds "little pattern to the exclusion of strikes in these reports," which suggests that there is no selection problem, but he warns that the reports may give "a distorted picture" (Bailey, 1991 pp. 438, 440). Another concern is the possible endogeneity of the fraction of employees striking and the use of replacement workers. As Card and Olson (1995 p.50) point out, "a larger fraction of workers may have been willing to participate in strikes that were perceived as likely to succeed." Similarly, a firm that intends never to surrender might replace all of its workers. Attempts to instrument for the two variables are described below.

[7] The true costs of the strikes, then, is likely even higher than Table 1 reports.

In order to be able to quantify the value of the "prize," we have included only strikes over wages. In those cases, the size of the disputed wage change being fought over is a measure of the prize. Roughly 48 percent (2113 out of 4410) of the strikes in the data set list the cause of the strike as either "for an increase in wages" or "against a decrease in wages." The rest of the strikes, where the strikers had goals such as achieving changes in working hours or conditions, preventing the hiring or firing of certain individuals, being paid overdue wages, or supporting a strike elsewhere, are dropped. Since the agents of the Commissioner of Labor recorded only actual pre- and post-strike wages, the proposed change in wages is not observed if the side opposing the change wins the strike. Thus, only pro-increase strikes won by the workers and anti-decrease strikes won by the firms are useable. 1108 of the 2113 wage strikes (53 percent) fall into one of those two categories. Note that this method of selection generates a biased sample, since there are many more strikes for increases than against decreases. For the 1108 strikes remaining in the sample, we construct two different measures of the "prize." The first is the absolute value of the difference between the pre- and post-strike wages; the second is that absolute value multiplied by the number of pre-strike employees. The first measure of the prize may have more relevance for the workers, and the second for the firms. Specifying the prize value this way requires that each side's optimal holdout time depends only on the magnitude of the proposed change, and not on its sign. That is, it assumes that there is no difference between a strike for a wage increase and one against a wage decrease of the same amount. It is not obvious that that assumption is accurate. Table 2 shows, for example, that unsuccessful strikes against wage decreases tended to last longer and occur at larger firms than successful strikes for

wage increases, and that they were more likely to involve strike breakers. In this model, however, identification depends on that assumption, and so it will be maintained. Of course, the empirical results are (at best) only as reliable as the assumption. A related concern is that the prize value may be endogenous – for example, the workers may demand the wage increase that maximizes their probability of winning the strike.

The *Third Report* classifies 1873 of the strikes over wages (89 percent) as either successes for the workers or failures; the remaining 11 percent are "partial successes." We recode partially successful strikes for wage increases as successes if the post-strike wage is at least ten cents higher than the pre-strike wage – half the mean wage increase in successful strikes. Similarly, we re-classify partially successful strikes against wage decreases as successes if the new wage is no more than ten cents lower than the old wage. Of the 237 "partial successes," 124 are changed to successes and the rest to failures.

For only 623 of the 1108 useable observations (56 percent) in Currie and Ferrie's data set have the names of the cities where the strikes took place been coded. An examination of the manuscript source suggests that that the names of only the larger cities and towns were recorded. New York and Massachusetts are exceptions: In those two states, the city name is recorded for every strike. In an attempt to make the data set consistent, we have removed the names of cities in New York and Massachusetts where fewer than two strikes are observed. After those changes, 594 of the observations (54 percent) contain both the city and the state; the remainder have only the name of the state.

To measure the value to a firm of forgone output during a strike, the fraction of employees striking, the dollar value of annual output, and the capital-labor ratio are used. Together, these variables are intended to measure what the firm is losing by having a

fraction of its labor force not at work. The greater the value of output, and the greater the fraction of that output attributable to the striking workers (that is, the greater the fraction striking and the lower the capital-labor ratio), the greater the cost to the firm of enduring a strike.[8] Output values and capital-labor ratios, not included in the *Third Report*, are constructed from the *Census of Manufactures*. Ideally, each firm in the *Third Report* would be matched up with its entry in the *Census of Manufactures*. However, the Atack-Bateman data are only samples of the *Census*; they do not include every establishment. Also, the *Third Report* does not include the names of the firms involved in strikes. In the absence of the ideal measure, industry- and location-specific averages are used. Where possible, county-level averages are used; when the city name is not available, state-level averages are used. In either case, firms with fewer than five employees (which are unlikely to suffer strikes) are excluded from the averages. For 34 strikes, state-level averages are used even though the city is known, because the *Census of Manufactures* sample does not include any firms with five or more workers in the relevant city-industry combination. A drawback of this approach is that the *Census of Manufactures* does not cover mining, quarrying, or transportation industries. Those three industries, which represent 29 percent (326 of 1108) of the sample, are lumped into "miscellaneous." Overall, 46 percent (509) of the strikes in the sample are classified as occurring in "miscellaneous industries," including 119 strikes where no industry is recorded.

The *Census of Manufactures* is also the source for the average wage paid to

[8] A high capital-labor ratio might also reflect the installation of new technology that reduces the firm's reliance on skilled labor, and in that way makes holding out easier. Alternatively, a high ratio may imply a high level of fixed costs in production, and thus a high cost of enduring a strike. We believe, though, that in estimation some of that effect may be captured by the output value and pre-strike wage variables, and thus that our original explanation for the role of the capital-labor ratio is likely to be valid. (We are grateful to a referee for raising these possibilities.)

unskilled workers, which serves as a measure of the alternatives available to striking workers. The average unskilled wage across firms, weighted by the number of employees, is calculated for each city and state. The pre-strike wage, taken from the *Third Report*, is a measure of what the workers are giving up by striking. The other measure of alternatives for striking workers is the local unemployment rate. That variable is constructed from the *Census of Population* microsample at the city or state level as the average number of months unemployed in the last year among unskilled non-agricultural workers. ("Unskilled non-agricultural workers" are those with an occupation code less than 59 in the 1880 census occupational classification system.) The *Census of Population* also gives the fractions of immigrants and non-whites in the area, which will be used to instrument for the use of replacement workers.

Currie and Ferrie (2000) provide the dates when unions were legalized in each state in the sample, ranging from 1869 to 1900 or later. The legislation in New Jersey, New York, and Pennsylvania was enacted before 1881; Maryland and Michigan legalized unions during the sample period, Maryland in April 1884 and Michigan in June 1883. An alternative measure of whether workers have attained the right to bargain collectively is whether there has been a previous successful strike (over any issue, not just wages) in the same industry and location.

Finally, strikes that occur in warm weather may be easier for strikers to endure, so we create a dummy for strikes beginning in the second or third quarter.

To reiterate: There are two measures of the prize, the size of the proposed wage change and the size of the proposed change in the wage bill. The observed determinants of the cost of striking to the workers are their pre-strike wage, the local unemployment

rate, the local unskilled wage rate, and the time of year. The determinants of the cost to employers are the fraction of employees on strike, the value of output, and the capital to labor ratio. The two measures of union recognition may also influence the value of winning the strike. That is, if winning gains workers not only a higher wage, but also the right to strike (and avoiding that outcome benefits the firm), then whether or not that right has already been established matters.

## Estimation

The parameters of equations 2a and 2b will be estimated in two different ways: estimating the probability of success ($T_f < T_w$) and estimating the duration of the strikes ($\min\{T_f, T_w\}$). The data set contains disproportionately many successful strikes. Since only successful strikes for wage increases and unsuccessful strikes against wage decreases are selected, and because there are considerably more strikes for increases than against decreases in the *Third Report*, a successful strike is more likely to be selected into the sample than an unsuccessful one. The data are weighted to correct for the resulting upward bias of estimated success probabilities. The method of weighting varies with the method of estimation.

**Probability of Success:** We estimate success probabilities in three ways, the probit method, linear regression, and nonparametric kernel estimation. The third method requires fewer assumptions than the other two.

*Probit*: The firm wins the strike if and only if $T_f > T_w$; the workers win if and only if $T_f < T_w$. (If $\varepsilon_f$ and $\varepsilon_w$ have continuous distributions, a tie is a probability zero event.) The probability that the workers win, therefore, is

$$\Pr[T_f < T_w] = \Pr[u < X_w W + X_f F + X_V V], \quad \textbf{(3)}$$

where $u \equiv \varepsilon_f - \varepsilon_w$, $W \equiv W_w - W_f$, $F \equiv F_w - F_f$, and $V \equiv V_w - V_f$. If the random variable $u$ is distributed normally with mean zero and variance $\sigma$ and is independent of the explanatory variables $X_w$, $X_f$, and $X_V$, then Equation 3 reduces to

$$\Pr[T_f < T_w] = \Phi(J / \sigma), \quad \textbf{(4)}$$

where $J \equiv X_w W + X_f F + X_V V$ and $\Phi$ is the standard normal cumulative distribution function. Equation 4 is the usual probit specification. (See, for example, Johnston and DiNardo, 1997.)

Under the null hypothesis that the war of attrition model is correct, the elements of the coefficient vectors $W$ and $F$ should have the same sign as the corresponding elements of $W_w$ and $F_w$: Suppose, for example, that an increase in variable $j$ decreases workers' costs. Then $W_{wj}$ will be positive, and $W_{fj}$ will be negative, so $W_j \equiv W_{wj} - W_{fj}$ is also positive. If increasing variable $j$ results in an increase in workers' costs, on the other hand, then $W_{wj}$ will be negative, $W_{fj}$ will be positive, and $W_j$ will also be negative. Thus, we can test the validity of the war of attrition model by estimating Equation 4, even though the individual coefficients $W_w$, $F_w$, $W_f$, and $F_f$ are not identified. The model does not pin down the sign of $V$. Because an increase in the value of the prize tends to

increase both sides' holdout times, the signs of $V_w$ and $V_f$ are the same, so the sign of $V \equiv V_w - V_f$ is indeterminate.

To avoid the selection bias discussed above, the data are weighted as follows: Of the 2113 strikes over wages in the *Third Report*, 1506 are for an increase and 607 are against a decrease. That means that a successful strike makes it into the sample with probability 1506/2113 (71.3%), and an unsuccessful strike is included with probability 607/2113 (28.7%). The inverses of those probabilities are the weights assigned to observations of successful and unsuccessful strikes, respectively.

*Linear Regression:* The probability that the workers win the strike can also be modeled as a linear function of the explanatory variables, plus an unobserved term *e*, which is independent of the explanatory variables and has mean zero:

$$\Pr[T_f < T_w] = X_w W^{\text{OLS}} + X_f F^{\text{OLS}} + X_V V^{\text{OLS}} + e. \quad \textbf{(5)}$$

The predicted signs of the coefficient vectors are the same as in probit estimation. The weighting method to adjust for selection bias is also the same.

*Nonparametric Kernel Estimation:* The nonparametric kernel method is a way to estimate a version of Equation 3 without assuming that holdout times are linear in the covariates. The estimated value of the dependent variable evaluated at a fixed vector of explanatory variables $X_0$ is the weighted average of the realizations of the dependent variable at values near $X_0$. That is, the predicted probability of strike success, $\hat{y}(X_0)$, is

$$\hat{y}(X_0) = \frac{\sum_{i=1}^{N} w(X_0 - X_i) y_i}{\sum_{i=1}^{N} w(X_0 - X_i)},$$

where $N$ is the number of observations, $y$ is the dummy variable equal to 1 if the workers won the strike, $X$ is the vector of explanatory variables, and $w(\cdot)$ is the kernel, which weights the observations according to their distance from $X_0$. The kernel used here is the density function of a normal distribution with mean zero and variance 0.195. The value 0.195 is the cross-validated bandwidth, which minimizes the sum of squared prediction errors when the predicted probability for each $X_i$ is calculated excluding observation $i$.

Because of the sample selection problem, each predicted probability $\hat{y}(X_0)$ is biased upward. Assume that the true probability that a strike succeeds is $\alpha$. Then because a successful strike makes it into the sample with probability 1506/2113, and an unsuccessful strike is included with probability 607/2113, the probability of success in the data, $p$, will be $\frac{\frac{1506\alpha}{2113}}{\frac{1506\alpha}{2113} + \frac{607(1-\alpha)}{2113}}$. Inverting that relationship yields $\alpha = 607/(1506 - 899p)$. Thus, the estimated success probability $\hat{y}(X_0)$ must be modified as follows to obtain an unbiased estimator $\hat{y}_U(X_0)$:

$$\hat{y}_U(X_0) = \frac{607}{1506 - 899\hat{y}(X_0)} \quad . \qquad \textbf{(6)}$$

This method of estimation relaxes the assumption that holdout times are a linear function of the independent variables, so the war of attrition model cannot be tested

simply by checking the signs of coefficients. Instead, kernel estimates of Equation 6 will be used to measure the average derivatives of success probability with respect to the explanatory variables. The average derivative over the 10th- to 90th-percentile range of variable $X_j$ is estimated as follows: $PH_j$ is the estimated success probability evaluated at the 90th-percentile of $X_j$ ($X_{j90}$) and the means of the other variables, and $PL_j$ is the estimated success probability evaluated at the 10th-percentile of $X_j$ ($X_{j10}$) and the means of the other variables. The average derivative is calculated as $(PH_j - PL_j) / (X_{j90} - X_{j10})$.

**Strike Duration:** The length of the strike is the minimum of the two holdout times. The war of attrition model predicts that duration increases with the value of the prize. It also predicts that if one side is perceived to have significantly lower costs, then the other side is likely to give in quickly. Conversely, if the two sides are evenly matched, then the strike is likely to be dragged out. Both predictions are tested using linear regression. We use the predicted success probability from probit estimation as our measure of whether or not the strike is closely contested. Weighting is as with the probit.

## Results

The results from applying the procedures described in the previous section to the data are shown in Table 4. Columns 1 and 2 present the results of linear and probit estimation of Equation 4 and 5, where the explanatory variables are the pre-strike wage (WAGE_PRE), the fraction of employees striking (FRACOUT), the average wage to unskilled labor in the region (USKILL_W), the firm's capital-labor ratio (KLRATIO), the value of the firm's output (OUTPUT_V), the local unemployment rate (MUE),

whether unions were recognized (PREV and LEGAL, as well as the interaction PREVLEG), whether the strike began in the spring or summer (Q2Q3), and the two measures of the prize value. (The absolute value of the wage change is PRIZE1; PRIZE2 is PRIZE1 multiplied by the number of pre-strike employees.) Also included are regional dummy variables for the Midwest (MW=1 for strikes in Illinois, Indiana, Michigan, and Ohio) and New England (NE=1 in Connecticut, Massachusetts, Maine and New Hampshire). The excluded region is the Middle Atlantic (Delaware, Maryland, New Jersey, New York, and Pennsylvania).[9]

In preliminary estimates, the fraction striking (FRACOUT) and the use of replacement workers were instrumented for, using the fraction of female employees and the fraction of immigrants and non-whites (the usual sources of strikebreakers) in the local population. The magnitude on the FRACOUT coefficient increased (as did the standard deviations), suggesting that the concern that more employees join in strikes that seem likely to succeed, thus biasing the coefficient upward, can be ignored. The coefficient on the use of replacements, on the other hand, moves from significantly negative to smaller in magnitude and insignificant. Our interpretation is that all firms had the *opportunity* to hire replacements. Whether or not they were used does not affect the firm's cost, but instead reflects the firm's belief about the eventual outcome. Consequently, in the reported regressions below we include FRACOUT without instruments and exclude the variable indicating the use of replacements.

The war of attrition model predicts that the coefficients on the variables that increase the workers' cost of striking (WAGE_PRE and MUE) or decrease the firm's

[9] We also tried alternative specifications, such as entering the two prize variables one at a time, and including a time trend. The results changed very little.

cost of enduring a strike (KLRATIO) should be negative. The coefficients on variables that decrease the workers' cost (USKILL_W and Q2Q3) or increases the firm's (FRACOUT and OUTPUT_V) should be positive. The model makes no prediction about the effect of the prize value or the regional and union recognition dummy variables.

All of the estimated coefficients in Columns 1 and 2 have the predicted sign, and six of them (FRACOUT, USKILL_W, KLRATIO, OUTPUT_V,[10] MUE, and Q2Q3) are significant at the one-percent level in both regressions. The coefficient on WAGE_PRE is significant at the five-percent level in the linear regression and at the ten-percent level in the probit specification. The null hypothesis that the war of attrition is the correct model of wage strikes in the 1880s is not rejected by linear or probit estimation.[11]

Column 3 presents the average derivatives of strike success probabilities with respect to the explanatory variables estimated nonparametrically. A 95-percent confidence interval for each average derivative is constructed from 100 bootstrap samples. The results are generally consistent with the probit results, although several of the estimated derivatives are considerably smaller in magnitude than the probit estimates. All of the estimated derivatives have the predicted sign, and six of them (FRACOUT,

[10] For the 46 percent of the strikes in the sample occurring in "miscellaneous industries," KLRATIO and OUTPUT_V are constructed from location-specific but not industry-specific averages. That construction may generate excessive noise in estimation, so we re-do the linear regression of strike success in Table 4, including a dummy variable for "miscellaneous industry" and interactions between the dummy and KLRATIO and OUTPUT_V. The new estimates remain consistent with the war of attrition, although the coefficients on both KLRATIO and OUTPUT_V are reduced in magnitude. The noise in the constructed variables does not qualitatively affect the results, but there is a quantitative impact, and so the estimated effects of the two industry variables on strike outcomes must be interpreted with caution.

[11] To address concerns about the omission of so many observations (we drop 1001 of 2109 wage strikes because the prize is not observed), we re-estimate the linear regression of strike success in Table 4 without the explanatory variables PRIZE1 and PRIZE2, and then use the estimated coefficients to generate predicted success probabilities for all 2109 wage strikes. The mean predicted probabilities of success for successful and failed pro-increase strikes are 53.2 percent and 49.2 percent, respectively. The means for successful and failed anti-decrease strikes are 45.2 percent and 38.3. The finding that workers were in a weaker position in both pro-increase and anti-decrease strikes that they in fact went on to lose suggests that the exclusion of so much of the data set does not qualitatively affect our conclusions.

USKILL_W, KLRATIO, OUTPUT_V, MUE, and Q2Q3) are significantly different from zero at the five-percent level. Nonparametric estimation of average derivatives, like probit and linear probability estimation, does not reject the hypothesis that the data fit the war of attrition model.[12]

The results of a linear regression of strike duration on the two measures of the prize value and other covariates are given in Column 4. The coefficients on both PRIZE1 and PRIZE2 are positive, and the one on PRIZE2 (the absolute value of the wage change times the number of employees) is greater than zero at the one-percent significance level, which is consistent with the prediction of the war of attrition model. The coefficient on the dummy variable CLOSE10 (which equals 1 if the predicted success probability from the probit regression is between .4 and .6, indicating that the sides are evenly matched) is positive, as the model predicts, and significant at the five-percent level.[13] The coefficients on the two union recognition dummies, PREV and LEGAL, are both negative, and the latter is significant at the one-percent level, which supports the idea that part of the prize at stake in the strikes is whether or not workers can establish their right to bargain collectively: strikes are shorter if that issue has been settled previously. Also consistent with that story is the fact that the coefficient on the interaction term, PREVLEG, is positive (although not quite significant at even the ten-percent level). Once the right to bargain has been established by either legislation or a successful strike, re-establishing it another way has little effect.

[12] As described earlier, an alternative theoretical interpretation of the effect of a higher capital-labor ratio is that it increases rather than decreases the firm's cost of holding out. In that case, the predicted coefficient of KLRATIO in Columns 1 through 3 is positive, and all three estimates would reject the war of attrition model.

[13] Other ways of defining the "closeness" of a strike yield similar results, as does using the log of duration as the dependent variable.

## Alternative Models

The main game-theoretic alternatives to the war of attrition model are models of signaling and screening (Kennan and Wilson, 1989). In those models, only one side lacks information about the other, as opposed to the war of attrition, where both sides are hampered by uncertainty. Usually, the firms are modeled as being of different "types": some have high profits and can afford to pay high wages, and some have low profits and can only afford low wages. Each firm knows its own type. Its workers, who are ignorant of the firm's type, begin by demanding a high wage. The firm can convince the workers that it cannot afford to pay such high wages (that it is a "low" type) only by showing that it would rather suffer the cost of a strike than pay. The lower the profits of the firm, the lower are its costs of enduring a strike and the greater its difficulty in paying a high wage. These discrimination models imply that the post-strike wage should decrease monotonically as the duration of the strike increases. The wage that the workers are willing to accept is lower after each day of the strike, because only lower type firms are willing to endure longer strikes in order to pay a lower wage. The strike lasts until the savings from the additional decrease in the workers' wage demand from one more day of a strike is less than or equal to the firm's cost of enduring another day, at which point it is optimal for the firm to agree to the employees' demands and end the strike.

In a variation on those models, it is the workers who are of different types, in the sense of having different outside options. In that case, the post-strike wage should increase with strike duration, as firms become convinced that the workers are of the "high

outside option" type. A key characteristic of the one-sided incomplete information models of strikes is that wage outcomes vary monotonically with strike duration.

Column 5 of Table 4 presents the results of ordinary least squares regression of post-strike wage on duration, squared duration, and other covariates. The sample used in the regressions in Column 5 includes all 2113 strikes over wages before 1887 in Currie and Ferrie's data set, regardless of which side won (except for four strikes where the post-strike wage is not recorded). According to the estimates, the post-strike wage is decreasing with duration for the first 300 days, and increasing thereafter. That result is inconsistent with a model in which workers are signaling their type to the firms. Because only 8 out of 2109 strikes in the sample lasted longer than 300 days, the data do not show conclusively that post-strike wages are not decreasing with duration, which would rule out models where it is the firm's type that is unknown. However, the estimated magnitude of the derivative of the post-strike wage with respect to duration seems to be inconsistent with such screening models. By enduring an additional day of a strike, a firm can reduce the daily wage by less than 0.14 cents. The average number of employees in the sample is 336, and the average annual value of output is $88,369. If the firm loses 1/365 of its annual output for each day of a strike, those figures imply that it will take over 16 months of seven-day work weeks for the average firm to recover in wages what it loses in output from an additional day of a strike. For the median firm, the figure is over 34 months. Of course, it is unlikely that a firm loses all of its output during a strike, but even if the true figures are only a fraction of the ones estimated, it appears

that the marginal cost to a firm of enduring one more day is far greater than the marginal gain. That result suggests that the data do not fit a screening model of strikes.[14]

Also, if there is uncertainty only about the firm's profitability and not about the workers' costs of enduring a strike, then the workers have no reason to signal their willingness to hold out longer. The qualititative evidence presented earlier of employees trying to display their ability to hold out is thus inconsistent with screening. Analogously, firms' attempts to downplay their costs of a strike do not fit the signaling model. Empirically, determinants of strike costs for both sides influence strike outcomes, suggesting that signaling and screening models, or any other model that relies on one-sided uncertainty, cannot explain the data. (The war of attrition, in contrast, posits two-sided asymmetric information.) Finally, the rarity of compromises seems to rule out signaling and screening models, in which the parties' offers and demands change over time.

Other alternatives to the war of attrition are models in which the sides can communicate with each other during the strike, modify their demands, and reach a compromise solution. It is difficult to tell from the data whether or not the sides were negotiating with each other, since only the final agreed-upon wage is reported. Most likely, firms and workers were bargaining with each other in at least a few of the strikes in the sample. Overall, though, the low proportion of strike outcomes that the Commissioner of Labor's agents classified as compromises and the historical evidence presented earlier suggest that such negotiation was rare.

[14] A similar "rationality" criterion is not appropriate to test the war of attrition model. The reason is the payoff discontinuity in the war of attrition: conceding one second before rather than one second after the other side yields a much lower payoff, and so marginal analysis does not apply. The signaling model, on the other hand, predicts a smooth change in wage as time passes.

## Why Wars of Attrition?

Because a war of attrition imposes costs on both sides that could be avoided if the parties could resolve their differences through a bargaining solution, the model best fits situations where the two sides have opposing goals or are antagonistic (as is the case with competing firms, or whenever the prize in dispute is indivisible), or where negotiation is difficult or impossible (as in public good provision for a large population). Relations between employers and employees do not usually fall into either of those categories. The conclusion of this paper, that the wage strikes of the 1880s have the properties of the war of attrition, raises a question, therefore: What was the source of the failure in labor relations? Why were firms and workers so rarely able to reach agreements through bargaining in the 1880s as opposed to the period from 1938-41, for example, when 36 percent of strikes ended in compromises (Edwards, 1981 p.42)?

Card and Olson (1995) suggest that many of the strikes of the 1880s were in fact over the issue of whether firms would even recognize that their employees had the right to bargain at all. Selekman (1927) says that such strikes "[have] to be fought out …. Agreements can be reached only by the abandonment of one side or the other of the matter of contention, there being no ground for a common point of view" (quoted in Hiller, 1928 p.199). For that interpretation to make sense, the "right to bargain" must be understood to include the right (or ability) to strike: It is in a firm's own best interest to bargain with workers who credibly threaten to strike. If Card and Olson's (1995) interpretation is correct, then, firms sought to win strikes in the belief that their employees, if defeated, would be so demoralized as to never strike again (or at least not

for a long time). Commons et al. (1926, p.350) report that after a failed strike employers took steps to prevent workers from organizing again: " … the employers would persecute the leaders as well as the common strikers through the blacklist, and those who remained were compelled to sign the 'iron-clad,' and were constantly spied upon." In any case, the regression of strike duration in Table 4 shows that although strikes are shorter when union recognition has been achieved (reflected in the negative coefficients on PREV and LEGAL), prize value is still an important explanatory factor. Thus, the right to bargain collectively may have been part of the motivation for the strikes, but it does not appear that the strikes were *exclusively* about recognition.

An implication of Card and Olson's (1995) explanation is that the probability of a strike ending in compromise should increase after union recognition.[15] To investigate, we regress the probability of a compromise outcome on the same set of independent variables used in the duration regression in Table 4. The estimated coefficients on PREV, LEGAL, and PREVLEG are respectively –.111, –.132, and .134. The coefficient on PREV is statistically significant at the five-percent level, and the other two at the ten-percent level. Thus, the data reject Card and Olson's (1995) hypothesis – the establishment of collective bargaining rights *reduces* the likelihood of compromise by over ten percent. (As in the duration regression, the coefficient on the interaction term PREVLEG is nearly equal in magnitude to the coefficients on PREV and LEGAL, but of the opposite sign: the right to bargain can only be established once.)

An alternative explanation of why the strikes were wars of attrition is that

[15] Freeman (1998) similarly argues that higher union densities reduced employer resistance to organized labor, since as more and more firms were unionized, recognizing organized labor was less likely to put any single firm at a competitive disadvantage.

employers and employees did not negotiate because they did not trust each other to abide by their agreements. The factory system of production had been introduced in the United States before the Civil War, but the large increase in the scale of manufacturing came afterward (Margo, 1992 p.28). Not until the 1880s was the factory system in general use (Commons et al, 1926 p.358). This change in the method of production resulted in "vastly larger" social gaps between workers and firm owners (Margo, 1992 pp.29-30). The willingness of owners to use violence to discourage strikers and the bodily harm sometimes inflicted upon strike breakers must also have contributed to an atmosphere of animosity and suspicion.[16] The fact that written employee contracts were uncommon before the 1890s magnified the difficulties caused by the mutual mistrust (Margo, 1992 p.35), and what labor contracts there were in most states were considered to be "court-unenforceable gentlemen's agreements" (Gould, 1993 p.31). Whatever the reason, in some cases mistrust was justified. In 1885 the Knights of Labor won a strike against Jay Gould's Wabash Railroad, which reversed a wage cut for shopmen and granted recognition to the Knights. Gould soon began to sabotage the agreement, however, by firing union officials. In 1886, the railworkers struck again, this time unsuccessfully. In May 1886, Chicago packinghouse workers won the eight-hour day (without a strike), but in October the meatpacking firms announced a return to the ten-hour day. The subsequent lockout was a complete victory for the firms (Perlman, 1922 pp. 94-98).

As Figure 2 shows, after the 1880s the rate of compromise in strikes gradually increased, and the war of attrition model became less and less applicable for describing strikes. (See Geraghty and Wiseman, 2007, for details about the rise of compromises.)

[16] See Rosenbloom (1998) on the use of strikebreakers in these strikes.

Examining how strikes moved away from the costly war-of-attrition framework can also shed light on why the strikes of the 1880s did take that form. Three main forces seem to be responsible for the transition: changes in macroeconomic conditions, evolution of the structure of product markets, and a growing awareness (by firms and workers, and also by government and the public) of the cost of wars of attrition.

As described earlier, deflation and high unemployment characterized the period from 1800 to 1896. Afterward, growing consumer demand and rising prices made it easier for firms to accept wage increases (or to forgo wage concessions from workers). Nominal wages, in fact, grew four times faster from 1897 to 1904 than from 1880 to 1896 (Griffin 1939). Table 5, which uses Freeman's (1998) periodization of U.S. labor history into periods of relative stasis or equilibrium (1880-1896, 1905-1915) punctuated by shorter union growth spurts (1897-1904, 1916-1921, 1934-1939), shows that changes in the frequency of compromised strikes are positively correlated with changes in the inflation rate. Intuitively, when there is a greater potential surplus, dividing it cooperatively is easier.

The same pattern shows up in looking at changes in industrial organization: with a larger pie, there is less incentive to fight for every bite. At the beginning of the 1880s, product distribution was typically dominated by wholesalers. The wholesalers invested in advertising, creating sales forces, and building networks with banks; few manufacturers were yet able to do the same. Wholesalers often used their market power to "play off competing manufacturers against each other, producing a cutthroat competition, low prices, low profits, and consequently a steady and insistent pressure upon wages" (Commons et al., 1926 pp. 359-360). The surplus available to

manufacturers and their employees was small, and compromise was rare. By the late 1890s, however, as the scale, scope, and market power of manufacturing enterprise increased, more firms were "reach[ing] out directly to the ultimate consumer, or, else, by means of control over patents and trademarks," had limited the power of the wholesaler (Commons et al., 1926 pp. 480-482). With the middlemen cut out of the loop, the profit margins of manufacturers increased, and so did the number of compromises.

At the extreme, though, in some industries manufacturers organized themselves into trusts. A leading example is the iron and steel industry, dominated after 1900 by the U.S. Steel Corporation (Commons et al., 1926 pp.359-360). In those industries, cooperation among firms (particularly in wage-setting) greatly reduced their costs of enduring strikes, and thus eliminated their incentive to compromise. We expect, then, to see an inverted-U-shaped relationship between the frequency of compromise and the level of concentration in an industry. The strikes in Currie and Ferrie's dataset exhibit just such a relationship, as Figure 5 shows. In particular, the industries with the lowest four-firm concentration ratios (printing, with a ratio of 1 percent) and with the highest (building, 57 percent) have compromise rates well below average: 2.9 percent and 6.8 percent, respectively.

Finally, compromises became more frequent as the high costs of the war of attrition became more apparent. "As a result of the increase in strikes," argues Barnett (1912, pp.426-427), "a widespread movement for the peaceful settlement of the conditions of employment was inaugurated . . . a considerable number of employers' associations formed originally for other purposes began to negotiate with the unions." In the Hocking Valley of Ohio, the "terrible destitution" of the 1884 coal miners' strike

described in the introduction led miners and operators to resolve at a convention in 1885 that, "[t]he question of what one should pay and the other receive in compensation can be best determined by friendly conferences, where intelligence and arbitration will take the place of the usual irrational and cruel methods of the past" (Bemis, 1888 pp.27-28). One manifestation of that "movement for peaceful settlement" was the increased use and acceptance of written contracts. Another important component was the creation by different levels of government of new mechanisms to resolve disputes between labor and management. For example, as the *New York Times* (1897a) reported on the 1897 coal miners' strike,

> The greatest interest is now manifested in the scheme to arbitrate the strike question. Labor commissioners and official arbitrators of the several states affected are now mobilizing … . Invitations have been sent to the coal operators of the Pittsburgh district to meet the arbitrators informally and talk over the matter of settling the strike. … If the operators can be brought into line on the conference idea, there will be no obstacles interposed by the miners.

The resulting compromise ending the strike included a wage increase less than the miners were originally seeking and an agreement by employers not to import new workers into areas affected by the strike (*New York Times* 1897b).

The ability of government to act as an impartial arbitrator is crucial in establishing such dispute resolution mechanisms, since once engaged in a war of attrition neither side

can independently propose a compromise without signaling weakness. At the beginning of the 1880s, though, government was typically not perceived as impartial: It was on the side of business. The famous Homestead strike of 1892, in which Carnegie Steel faced off against the Amalgamated Association of Iron and Steel Workers, and the Pullman strike of 1894 both failed in part after intervention by state militias and, in the latter case, federal troops (Perlman, 1922 pp.83-85, 97-100, 133-139; Commons et al., 1926 pp.495-497, 502-503). Taft (1964 p.162) suggests that the depression years of 1893 to 1898 may have played a role in changing public and governmental perception of organized labor:

> Prolonged unemployment, with its accompanying destitution and suffering, tarnished the reputation of business, and the public regarded, at least for a time, the workers' quest for greater security and higher pay as justifiable. Exposures of corporate derelictions made the demands of labor for some countervailing power appear reasonable.

Overall, then, it seems that wage strikes in 1880s America were wars of attrition because neither side trusted the other to honor agreements, because narrow profit margins left little room to compromise, and because neither side could unilaterally propose a move toward compromise. Over time, changes in market structure and macroeconomic conditions, together with a push for less costly, arbitrated settlements by the public sector, relieved those pressures, and strikes ceased to be wars of attrition.

## Summary and Discussion

It is clear that the estimated equations do not contain all the covariates that would ideally be included. Most obviously, firm-specific data on revenues and capital-labor ratios would be an improvement. The possibility of selection bias in the *Third Report* raised by Bailey (1991) is also a concern, as is the potential inaccuracy of the identifying assumption that holdout times depend only on the magnitude (and not on the sign) of the proposed wage change. The limitations of the existing data set must be kept in mind when considering the conclusions of this paper: Based on regressions of maximum holdout times and strike duration on determinants of strike costs and prize value, the hypothesis that the wage strikes of the 1880s fit the war of attrition model is not rejected. Alternative game-theoretic models of one-sided incomplete information do not fit the data. The strikes took the form of wars of attrition not because they were chiefly over recognition of collective bargaining rights, but because of three factors: lack of enforceable agreements, small surpluses to be split, and the absence of an impartial arbitrator.

The observation that the 1880s strikes were wars of attrition implies that two-sided rather than one-sided incomplete information played an important role. That bilateral uncertainty may help to explain why there were so many strikes during the period. A strike, in some sense, is always a mistake. The two sides undertake the strike because each believes that the outcome will make it better off. At least one side must be wrong, because the costs of the strike reduce the economic surplus; in fact, a long strike makes even the winner worse off. When both sides face uncertainty, then either can be wrong in its expectation. Thus, when strikes are wars of attrition, there will be more of

them than if they fit the signaling or screening models, which feature incomplete information on only one side: Two uncertain parties means twice as many chances for mistakes.

In conclusion, it is interesting to note that the three factors identified in this paper as leading to war-of-attrition strikes are becoming relevant again, as capital moves more and more freely across the world and information technology increases flexibility in production. When production of a final good takes place in more than one country, it is not always clear which set of labor laws apply, and there is no obvious arbitrator. Even worse, if a company has its headquarters in one country and its workers in another, then neither government is impartial in a dispute between labor and management. Similarly, a firm that can easily shift a manufacturing plant to a low-wage country can avoid honoring its contract with a union in a high-wage country. (See, for example, Varman and Chakrabarti (2003) and Piazza (2005)). Finally, increased global competition squeezes the profit margins of producers. More generally, Cutcher-Gershenfeld and Kochan (2004 p.25) argue that "collective bargaining is being challenged by changes occurring in the nature of work and the economy." Thus, the strikes of the 21st century may again fit the war of attrition model.

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**Table 1**
Strike Costs

| | Total Cost (current$) | | Cost per indiv | |
|---|---|---|---|---|
| **Year** | **Workers** | **Firms** | **Worker** | **Firm** |
| 1881 | $1,760,618 | $1,057,506 | $24 | $866 |
| 1882 | $7,289,799 | $2,479,789 | $79 | $2,572 |
| 1883 | $4,106,315 | $2,407,230 | $56 | $1,820 |
| 1884 | $5,093,905 | $2,234,003 | $68 | $1,845 |
| 1885 | $8,195,692 | $2,619,137 | $59 | $1,898 |
| 1886 | $8,571,346 | $5,834,991 | $33 | $1,317 |
| 1887 | $11,647,108 | $3,964,555 | $69 | $1,011 |
| 1888 | $5,541,202 | $6,219,531 | $81 | $2,075 |
| 1889 | $8,009,986 | $1,942,858 | $56 | $725 |
| 1890 | $11,175,405 | $3,503,671 | $62 | $642 |
| 1891 | $12,497,132 | $5,160,108 | $60 | $772 |
| 1892 | $8,899,130 | $4,241,542 | $78 | $1,027 |
| 1893 | $7,977,051 | $3,170,246 | $66 | $801 |
| 1894 | $20,478,079 | $12,559,716 | $103 | $2,886 |
| **Total** | $121,242,768 | $57,394,883 | | |
| **Average** | $8,660,198 | $4,099,635 | $64 | $1,447 |

| | Total Cost (2004$) | | Cost per indiv | |
|---|---|---|---|---|
| **Year** | **Workers** | **Firms** | **Worker** | **Firm** |
| **1881** | $29,280,646 | $17,587,267 | $398 | $14,404 |
| **1882** | $117,916,034 | $40,111,790 | $1,272 | $41,610 |
| **1883** | $69,160,145 | $40,543,499 | $943 | $30,645 |
| **1884** | $89,471,388 | $39,238,924 | $1,188 | $32,402 |
| **1885** | $147,346,546 | $47,088,250 | $1,054 | $34,122 |
| **1886** | $154,976,543 | $105,501,135 | $604 | $23,804 |
| **1887** | $209,977,648 | $71,474,218 | $1,248 | $18,219 |
| **1888** | $97,925,876 | $109,913,521 | $1,438 | $36,675 |
| **1889** | $141,861,450 | $34,409,130 | $996 | $12,834 |
| **1890** | $202,122,204 | $63,368,594 | $1,121 | $11,612 |
| **1891** | $226,874,900 | $93,677,412 | $1,093 | $14,007 |
| **1892** | $163,491,033 | $77,923,807 | $1,435 | $18,863 |
| **1893** | $146,496,040 | $58,220,574 | $1,217 | $14,706 |
| **1894** | $397,047,586 | $243,519,176 | $2,001 | $55,956 |
| **Total** | $2,193,948,040 | $1,042,577,295 | | |
| **Average** | $156,710,574 | $74,469,807 | $1,143 | $25,704 |

**Table 2**

Characteristics of Successful Strikes for Wage Increases and Unsuccessful Strikes against Wage Decreases

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
|---|---|---|---|---|---|---|---|---|---|
| | Number | Fraction on Strike | Fraction Using Strike Breakers | Mean Pre-Strike Wage | Mean Change in Wage | Mean \|Change in Wage\| | Mean \|Change in Wage\| X # Workers | Fraction for Wage Increase | Median Duration |
| All Strikes | 1108 | 0.69 | 0.10 | 1.79 | 0.08 | 0.21 | 63.43 | 0.67 | 11 |
| By State | | | | | | | | | |
| CT | 73 | 0.25 | 0.04 | 1.49 | 0.06 | 0.09 | 14.59 | 0.82 | 5 |
| DE | 4 | 0.51 | 0.00 | 1.36 | 0.06 | 0.09 | 25.95 | 0.75 | 12 |
| IL | 215 | 0.92 | 0.07 | 2.00 | 0.16 | 0.24 | 59.85 | 0.78 | 7 |
| IN | 47 | 0.76 | 0.17 | 1.81 | -0.02 | 0.23 | 60.35 | 0.51 | 14 |
| ME | 9 | 0.63 | 0.11 | 1.70 | 0.19 | 0.19 | 27.37 | 1.00 | 7 |
| MD | 18 | 0.92 | 0.22 | 1.62 | 0.04 | 0.26 | 184.86 | 0.61 | 36 |
| MA | 34 | 0.41 | 0.15 | 1.54 | -0.16 | 0.26 | 97.24 | 0.18 | 27.5 |
| MI | 37 | 0.69 | 0.08 | 1.71 | 0.12 | 0.17 | 25.38 | 0.78 | 9 |
| NH | 4 | 0.23 | 0.00 | 1.55 | 0.06 | 0.12 | 227.90 | 0.75 | 16 |
| NJ | 55 | 0.78 | 0.02 | 1.84 | 0.15 | 0.23 | 28.98 | 0.75 | 7 |
| NY | 85 | 0.91 | 0.06 | 2.03 | 0.25 | 0.34 | 99.45 | 0.76 | 7 |
| OH | 209 | 0.67 | 0.20 | 1.76 | 0.04 | 0.22 | 69.21 | 0.64 | 14 |
| PA | 318 | 0.57 | 0.09 | 1.71 | 0.02 | 0.16 | 63.42 | 0.61 | 14 |
| By Year | | | | | | | | | |
| 1881 | 155 | 0.73 | 0.09 | 1.91 | 0.16 | 0.21 | 40.98 | 0.86 | 10 |
| 1882 | 141 | 0.73 | 0.10 | 1.87 | 0.11 | 0.22 | 44.77 | 0.69 | 9 |
| 1883 | 148 | 0.70 | 0.12 | 1.76 | 0.04 | 0.21 | 67.91 | 0.60 | 14 |
| 1884 | 124 | 0.62 | 0.19 | 1.83 | -0.15 | 0.24 | 127.25 | 0.20 | 14.5 |
| 1885 | 169 | 0.64 | 0.14 | 1.67 | -0.01 | 0.18 | 90.44 | 0.44 | 18 |
| 1886 | 371 | 0.69 | 0.05 | 1.75 | 0.16 | 0.20 | 44.49 | 0.88 | 7 |
| By Industry | | | | | | | | | |
| 1 | 111 | 0.49 | 0.04 | 1.43 | 0.11 | 0.13 | 43.78 | 0.84 | 7 |
| 2 | 79 | 0.73 | 0.11 | 1.87 | 0.12 | 0.19 | 33.63 | 0.72 | 7 |
| 3 | 114 | 0.71 | 0.08 | 1.58 | 0.10 | 0.18 | 12.85 | 0.79 | 14 |
| 4 | 204 | 0.48 | 0.15 | 1.86 | 0.06 | 0.16 | 32.59 | 0.67 | 13.5 |
| 5 | 14 | 0.56 | 0.21 | 2.11 | 0.14 | 0.25 | 13.56 | 0.71 | 8.5 |
| 6 | 77 | 0.74 | 0.12 | 2.13 | 0.17 | 0.25 | 99.90 | 0.87 | 7 |
| 7 | 509 | 0.79 | 0.10 | 1.80 | 0.05 | 0.24 | 91.89 | 0.58 | 12 |
| By Cause | | | | | | | | | |
| For Increase | 746 | 0.71 | 0.06 | | 0.21 | 0.21 | 53.46 | | 7 |
| Vs. Decrease | 362 | 0.63 | 0.19 | | -0.19 | 0.21 | 83.99 | | 24 |

Notes: Industry codes: 1=clothing, textiles, shoes, leather; 2=wood, glass, pottery; 3=food, tobacco; 4=metals, machinery; 5=printing; 6=construction, building; 7=other

Source: U.S. Commissioner of Labor (1888)

**Table 3**

Employment and Industrial Characteristics, by State and City

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) | (14) | (15) | (16) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Industry 1 | | Industry 2 | | Industry 3 | | Industry 4 | | Industry 5 | | Industry 6 | | Industry 7 | |
| | Mean Unskilled Wage | Mean Months Unemp. | Mean K/L | Mean Output Value | Mean K/L | Mean Output Value | Mean K/L | Mean Output Value | Mean K/L | Mean Output Value | Mean K/L | Mean Output Value | Mean K/L | Mean Output Value | Mean K/L | Mean Output Value |
| **CT** | 1.32 | 0.65 | 371 | 107522 | 1804 | 20523 | 1364 | 33825 | 1389 | 71895 | 930 | 58825 | 210 | 26022 | 765 | 87184 |
| Bridgeport | 1.35 | 0.31 | 188 | 70245 | 5240 | 21177 | 1377 | 11000 | 1626 | 73300 | * | * | 124 | 56000 | 514 | 322600 |
| Hartford | 1.35 | 0.46 | 331 | 106207 | 943 | 6533 | 1333 | 26000 | 1377 | 15954 | 1383 | 104500 | 292 | 30097 | 1319 | 31383 |
| New Haven | 1.37 | 0.94 | 511 | 240413 | 1081 | 109624 | 872 | 32112 | 1562 | 111013 | 577 | 14000 | 181 | 12711 | 722 | 74951 |
| **DE** | 0.98 | 0.25 | 1184 | 62201 | 413 | 6957 | 1234 | 35011 | 863 | 72341 | 417 | 5000 | 210 | 19450 | 975 | 43039 |
| **IL** | 1.16 | 0.44 | 591 | 104328 | 544 | 19843 | 1763 | 290062 | 1012 | 56231 | 371 | 68250 | 364 | 43891 | 2521 | 67338 |
| Chicago | 1.29 | 0.37 | 602 | 146218 | 533 | 38307 | 649 | 444764 | 1195 | 51742 | 436 | 85667 | 259 | 57161 | 515 | 110083 |
| Decatur | 1.00 | 0.22 | 375 | 40000 | * | * | * | * | * | * | * | * | * | * | 6908 | 11548 |
| E. St. Louis | 1.60 | 1.24 | * | * | * | * | 1867 | 785129 | * | * | * | * | 100 | 18000 | * | * |
| Peoria | 1.24 | 0.44 | * | * | 1611 | 16333 | 682 | 450000 | 1000 | 90000 | * | * | 832 | 51500 | * | * |
| Springfield | 1.18 | 0.56 | * | * | 125 | 2000 | 1667 | 14000 | * | * | 179 | 16000 | 1600 | 8926 | * | * |
| **IN** | 1.07 | 0.45 | 794 | 38692 | 349 | 28012 | 1034 | 85176 | 777 | 50230 | 650 | 29000 | 331 | 8371 | 495 | 22786 |
| Evansville | 1.17 | 0.46 | 1158 | 46800 | * | * | 1038 | 107262 | * | * | 1034 | 56000 | * | * | * | * |
| Indianapolis | 1.22 | 0.18 | 767 | 28500 | 325 | 159268 | 422 | 150425 | 922 | 76800 | * | * | * | * | 536 | 47000 |
| South Bend | 1.03 | 0.15 | * | * | 750 | 5000 | * | * | 1171 | 250000 | * | * | * | * | 417 | 7500 |
| Terre Haute | 1.19 | 0.39 | * | * | 150 | 18000 | * | * | * | * | 417 | 14000 | * | * | 363 | 28000 |
| **ME** | 1.04 | 0.59 | 398 | 64252 | 583 | 12438 | 385 | 61590 | 858 | 21748 | 1078 | 14460 | 176 | 8967 | 887 | 11845 |
| **MD** | 0.99 | 0.58 | 786 | 45392 | 481 | 35771 | 991 | 67507 | 921 | 77730 | 1506 | 35200 | 583 | 19414 | 1941 | 56166 |
| Baltimore | 1.06 | 0.46 | 508 | 38437 | 564 | 46525 | 1181 | 85177 | 1024 | 111262 | 1201 | 64668 | 583 | 19414 | 2475 | 74682 |
| **MA** | 1.25 | 0.59 | 662 | 60563 | 702 | 26984 | 1033 | 133789 | 751 | 43342 | 623 | 79694 | 462 | 29830 | 1965 | 86584 |
| Boston | 1.25 | 0.54 | 364 | 20994 | 457 | 32558 | 1593 | 284060 | 691 | 22251 | 393 | 113160 | 657 | 42848 | 1003 | 139783 |
| Fall River | 1.29 | 0.84 | 156 | 31200 | 350 | 11500 | 707 | 57800 | 782 | 53032 | * | * | 322 | 9666 | 2576 | 62612 |
| Springfield | 1.26 | 0.45 | 506 | 28667 | 895 | 42750 | 167 | 9075 | 495 | 60217 | 500 | 4000 | 1000 | 16000 | 1987 | 220000 |
| Worcester | 1.21 | 0.47 | 1094 | 60466 | 488 | 25431 | 643 | 30000 | 763 | 73453 | * | * | 233 | 24667 | * | * |
| **MI** | 1.17 | 0.39 | 701 | 114875 | 726 | 39699 | 2699 | 87098 | 978 | 19309 | 1736 | 10000 | 316 | 15798 | 1337 | 47376 |
| Detroit | 1.10 | 0.26 | 1233 | 365000 | 759 | 61492 | 3000 | 44600 | 724 | 53750 | 2941 | 20000 | 292 | 17046 | 599 | 60500 |
| Grand Rapids | 1.17 | 0.28 | 714 | 102000 | 774 | 26827 | * | * | 625 | 34000 | * | * | 171 | 10000 | 324 | 13000 |
| Lansing | 1.10 | 0.62 | * | * | * | * | * | * | 2000 | 2000 | 1600 | 5000 | * | * | 250 | 30350 |
| **NH** | 1.09 | 0.25 | 647 | 108765 | 447 | 24694 | 1018 | 32227 | 790 | 34901 | 525 | 7250 | 357 | 10980 | 1049 | 26959 |

**Table 3**
(continued)
Employment and Industrial Characteristics, by State and City

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) | (14) | (15) | (16) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Industry 1 | | Industry 2 | | Industry 3 | | Industry 4 | | Industry 5 | | Industry 6 | | Industry 7 | |
| | Mean Unskilled Wage | Mean Months Unemp. | Mean K/L | Mean Output Value | Mean K/L | Mean Output Value | Mean K/L | Mean Output Value | Mean K/L | Mean Output Value | Mean K/L | Mean Output Value | Mean K/L | Mean Output Value | Mean K/L | Mean Output Value |
| **NJ** | 1.12 | 0.52 | 416 | 116456 | 735 | 12410 | 1804 | 174602 | 628 | 44300 | 1015 | 81598 | 352 | 17878 | 1181 | 48551 |
| Camden | 1.18 | 0.28 | * | * | 750 | 7000 | * | * | 1321 | 21250 | * | * | * | * | * | * |
| Jersey City | 1.39 | 0.09 | 83 | 4500 | 533 | 17000 | 1024 | 517714 | 348 | 15362 | * | * | 195 | 23625 | 929 | 52500 |
| Newark | 1.17 | 0.79 | 578 | 102872 | 606 | 9748 | 2044 | 31000 | 417 | 22096 | 1019 | 118667 | 420 | 17264 | 904 | 84187 |
| Paterson | 1.17 | 0.30 | 250 | 220204 | 438 | 12000 | * | * | 788 | 320422 | 1017 | 41988 | * | * | 444 | 15500 |
| Trenton | 1.15 | 0.12 | 86 | 23500 | 714 | 19400 | 2599 | 270859 | 1228 | 11333 | * | * | 56 | 9850 | 881 | 27500 |
| **NY** | 1.09 | 0.34 | 754 | 94212 | 641 | 24490 | 1896 | 116407 | 873 | 63988 | 938 | 53250 | 588 | 21659 | 968 | 27765 |
| Amsterdam | 1.06 | 0.98 | * | * | * | * | 500 | 10000 | * | * | * | * | * | * | 986 | 97000 |
| Brooklyn | 1.38 | 0.24 | 1478 | 56501 | 1048 | 47597 | 924 | 23589 | 654 | 38099 | 353 | 28690 | 394 | 10669 | 1419 | 25210 |
| Cohoes | 1.50 | 0.38 | * | * | * | * | 8333 | 193000 | * | * | * | * | * | * | * | * |
| New York City | 1.30 | 0.27 | 700 | 117905 | 508 | 22850 | 1573 | 294983 | 784 | 138948 | 1110 | 73093 | 913 | 33882 | 494 | 41906 |
| Troy | 1.18 | 0.23 | 90 | 470000 | 441 | 10000 | 545 | 22190 | 1372 | 68750 | 500 | 4500 | 210 | 18250 | 606 | 5388 |
| **OH** | 1.03 | 0.56 | 520 | 25063 | 475 | 14234 | 1625 | 38385 | 857 | 30121 | 917 | 75062 | 318 | 12522 | 1234 | 27924 |
| Akron | 1.22 | 0.45 | * | * | 438 | 17467 | 3000 | 24000 | 253 | 13000 | 700 | 8500 | 1429 | 45000 | 1889 | 28090 |
| Cincinnati | 1.02 | 0.26 | 591 | 34642 | 524 | 22260 | 2064 | 45283 | 477 | 44221 | 1224 | 124865 | 438 | 16309 | 1436 | 41815 |
| Cleveland | 1.22 | 0.64 | 508 | 26807 | 523 | 17520 | 865 | 23820 | 1372 | 37521 | 250 | 9600 | 248 | 8717 | 7037 | 138250 |
| Columbus | 0.95 | 0.74 | 188 | 5100 | 408 | 37153 | * | * | 1835 | 54113 | 19 | 8000 | 304 | 11371 | * | * |
| Dayton | 1.21 | 1.49 | 500 | 13000 | 528 | 10221 | 3000 | 27900 | 919 | 38401 | 1533 | 100000 | 100 | 10000 | * | * |
| **PA** | 1.04 | 0.76 | 858 | 77747 | 819 | 30154 | 1430 | 229936 | 1022 | 109950 | 1335 | 19644 | 631 | 27054 | 1354 | 100421 |
| Allentown | 0.84 | 0.73 | 3000 | 13000 | 1000 | 15300 | 120 | 2500 | 400 | 1000 | * | * | * | * | * | * |
| Erie | 0.97 | 0.25 | * | * | 200 | 20288 | * | * | * | * | 71 | 9400 | * | * | 278 | 4700 |
| Philadelphia | 1.38 | 0.39 | 815 | 92100 | 882 | 37159 | 3100 | 668955 | 1151 | 45818 | 1717 | 22625 | 578 | 26507 | 2235 | 355201 |
| Pittsburgh | 1.25 | 1.16 | 485 | 67701 | 2944 | 129333 | 600 | 13228 | 1705 | 433169 | * | * | 1162 | 44030 | 3413 | 30716 |
| Reading | 0.83 | 0.72 | * | * | 500 | 3500 | * | * | 508 | 120843 | * | * | * | * | * | * |

Notes: Industry codes: 1=clothing, textiles, shoes, leather; 2=wood, glass, pottery; 3=food, tobacco; 4=metals, machinery; 5=printing; 6=construction, building; 7=other.
* : No observations
Columns 3-16 represent establishments with at least five employees.

Source: Atack and Bateman; Ruggles and Sobek (1997)

**Table 4**
Estimation Results

| | (1) Linear Regression of Success Probability | | (2) Probit Estimation of Success Probability | | (3) Kernel Estimation of Success Probability | | (4) Linear Regression of Duration | | (5) Linear Regression of Post-Strike Wage | |
|---|---|---|---|---|---|---|---|---|---|---|
| Variable | Coefficient | Robust Standard Error | dF/dX | Robust Standard Error | Average Derivative | [95% Confidence Interval] | Coefficient | Robust Standard Error | Coefficient | Robust Standard Error |
| fracout | .178*** | .049 | .211*** | .057 | .035 | [.019, .051] | -31.5*** | 8.45 | .080*** | .021 |
| prev | .115** | .050 | .129** | .053 | -.012 | [-.031, .003] | -5.30 | 4.71 | .036 | .023 |
| legal | .176* | .097 | .196* | .111 | -.015 | [-.058, .027] | -35.1*** | 10.6 | .242*** | .042 |
| prevleg | -.181** | .079 | -.195** | .083 | -.054 | [-.108, .003] | 11.3 | 7.98 | -.174*** | .034 |
| wage_pre | -.072** | .034 | -.076* | .039 | -.001 | [-.004, .003] | 13.2** | 5.39 | .785*** | .012 |
| uskill_w | .375*** | .132 | .441*** | .161 | .005 | [.003, .008] | -16.0 | 14.7 | .179*** | .059 |
| klratio | -.131*** | .021 | -.157*** | .029 | -.027 | [-.037, -.015] | 3.95* | 2.27 | -.023** | .010 |
| output_v | .432*** | .154 | .513*** | .197 | .151 | [.011, .264] | -49.5 | 16.9 | .095 | .080 |
| mue | -.368*** | .082 | -.398*** | .096 | -.051 | [-.062, -.039] | 5.70 | 7.81 | -.012 | .036 |
| prize1 | .006 | .091 | -.045 | .118 | .126 | [.071, .191] | 22.7 | 16.0 | | |
| prize2 | -.157** | .072 | -.177** | .098 | -.191 | [-.409, .011] | 52.0*** | 17.0 | | |
| Q2Q3 | .174*** | .031 | .187*** | .033 | .075 | [.039, .102] | -6.02 | 4.21 | .021 | .014 |
| MW | .022 | .089 | .039 | .103 | .015 | [-.032, .061] | -18.6** | 9.14 | .134*** | .035 |
| NE | .162 | .099 | .184 | .113 | .017 | [-.116, .142] | -44.5*** | 11.4 | .069* | .041 |
| close10 | | | | | | | 11.3** | 4.37 | | |
| duration | | | | | | | | | -.00138** | .0003 |
| dursq | | | | | | | | | .002*** | .001 |
| constant | .108 | .204 | | | | | 69.2*** | 23.2 | .043 | .088 |
| # of obs | 1108 | | 1108 | | 1108 | | 1108 | | 2109 | |
| R-squared | 0.153 | | 0.120 | | | | 0.106 | | 0.709 | |

NOTES:
fracout: fraction of employees striking
prev: dummy = 1 if previous successful strike in industry/location
legal: dummy = 1 if unions legal
prevleg: dummy = prev*legal
wage_pre: pre-strike daily wage ($)
uskill_w: average wage to unskilled labor in the area ($)
klratio: firm's capital-labor ratio ($1000/worker)
output_v: value of the firm's annual output ($million)
mue: local unemployment level (months/year)
prize1: absolute value of the wage change ($)
prize2: prize1 multiplied by the number of pre-strike employees ($1000)
Q2Q3: dummy = 1 if strike started April-September
MW: regional dummy for IL, IN, MI,OH
NE: regional dummy for CT, MA, ME, NH
close10: dummy = 1 if the predicted success probability from Column 2 is between .4 and .6
duration: duration of strike (days)
dursq: duration squared (1000 days)

*, **, ***: statistically significant at the .1, .05, and .01 levels, respectively

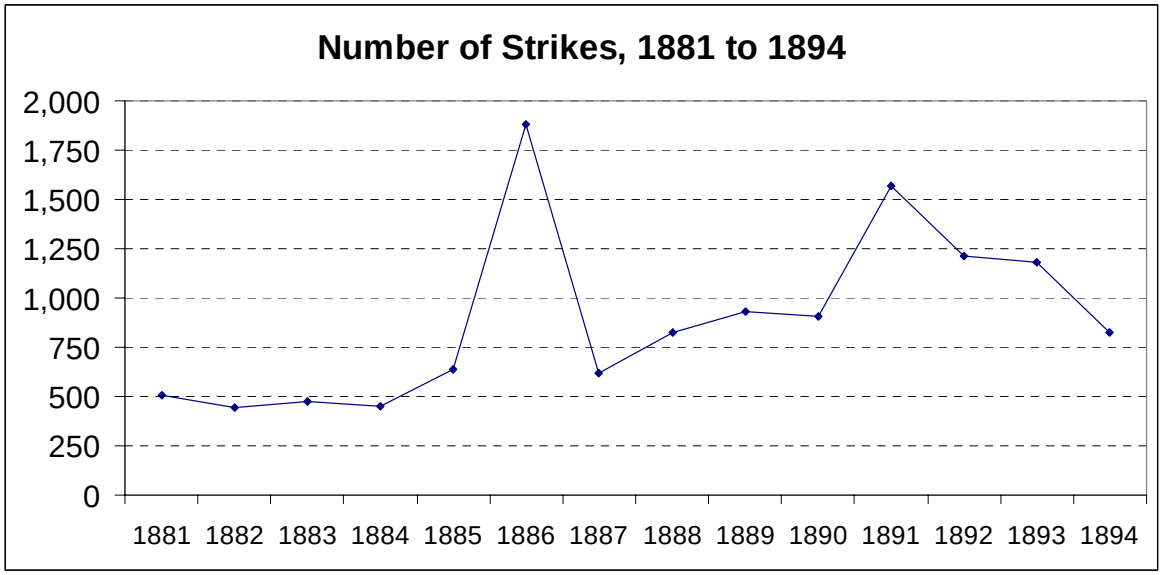
The average derivative in Column 3 is calculated as follows: For each variable X, PH is the estimated probability of strike success evaluated at the 90th percentile (X90) of X and at the means of the other variables. PL is the estimated probability at the 10th percentile (X10) and at the means of the other variables. The average derivative is (PH – PL)/(X90 – X10).

**Table 5**
Inflation Rate and Compromise Strikes
(Annual Averages)

| | | Compr. Strike Rate | Inflation Rate |
|---|---|---|---|
| 1880-1896 | equilibrium | 10.6% | -0.7% |
| 1897-1904 | growth spurt | 17.9% | 1.1% |
| 1905-1915 | equilibrium | 17.7% | 1.5% |
| 1916-1921 | growth spurt | 37.5% | 10.5% |
| 1922-1933 | decline | 26.8% | -2.6% |
| 1934-1937 | growth spurt | 30.5% | 3.3% |

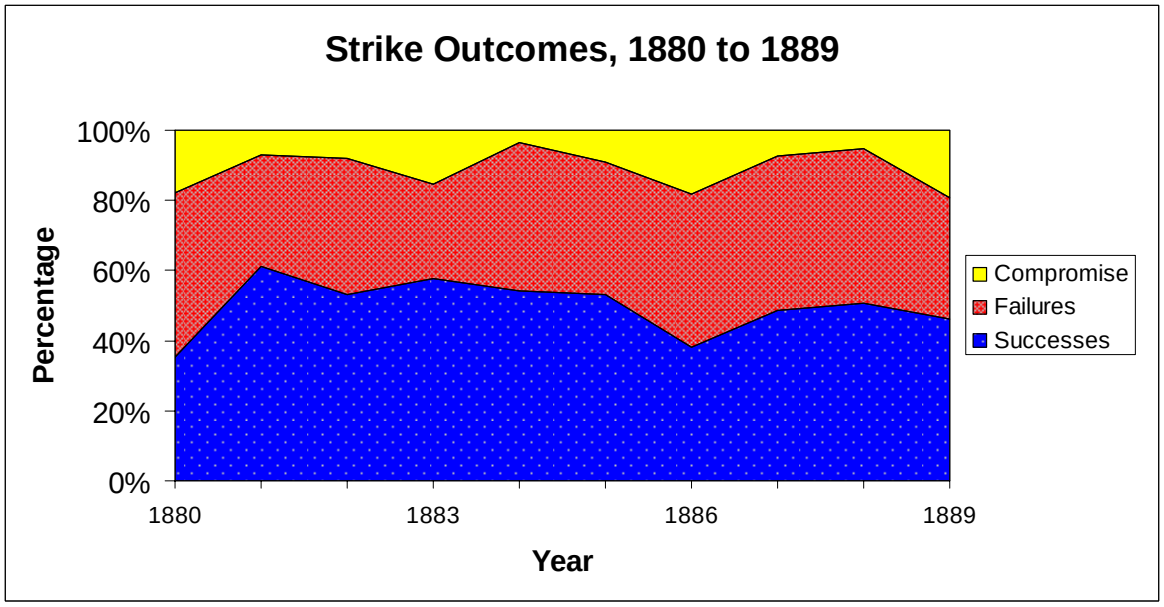
Sources: Griffin (1939), Gordon (2006)

Figure 1



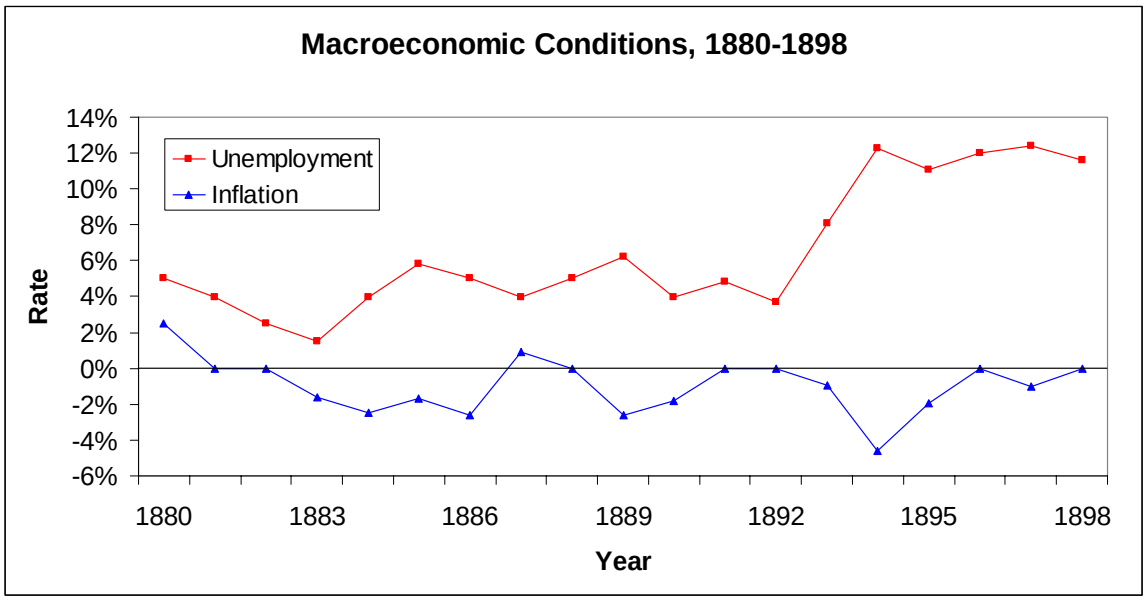

Source: U. S. Commissioner of Labor (1888, 1896)

Figure 2



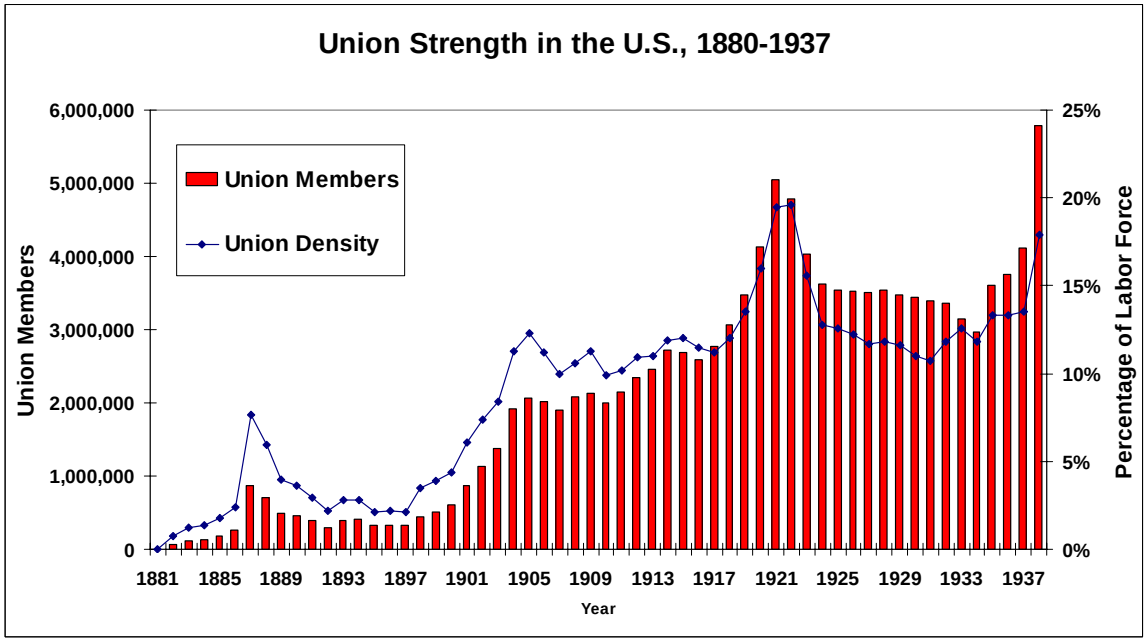

Source: Griffin (1939)

Figure 3



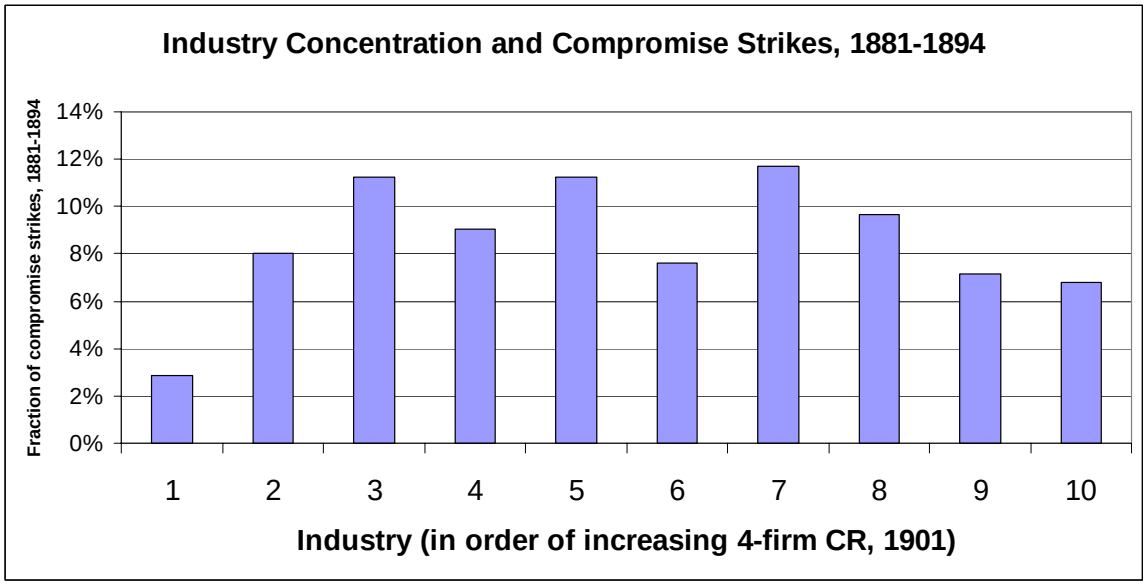

Source: Griffin (1939); DeLong (2000)

Figure 4




Source: Troy (1965)

Figure 5




Source: Atack and Bateman (2006), U.S. Commissioner of Labor (1888, 1896)

Note: Concentration ratios are medians of indicated industries for 1901. "1860 and 1947" indicates that ratios for 1901 were interpolated (linearly) from available data for 1860 and 1947.

| | | Compr. | 4-firm Conc Ratio (1901) | |
|---|---|---|---|---|
| **1** | Printing publishing telegraph | 2.9% | 1% | printing and publishing |
| **2** | misc | 8.0% | 3% | miscellaneous |
| **3** | Cooperage and wooden goods | 11.3% | 12% | furniture (1860 and 1947) |
| **4** | Glass and pottery | 9.0% | 13% | stone, clay, glass products |
| **5** | Clothing textiles shoes leather | 11.3% | 20% | cotton, wool, boots & shoes, leather, clothing (1860 and 1947) |
| **6** | Food prep and brewing | 7.6% | 39% | flour milling, meatpacking, liquor |
| **7** | Machines and machinery | 11.7% | 41% | agricultural implements, machinery |
| **8** | Metals and metallic goods | 9.7% | 46% | iron castings, iron bar |
| **9** | Tobacco | 7.2% | 50% | tobacco |
| **10** | Building trades and trans eqpt | 6.8% | 57% | trans eqpt |