The Rise and Fall of the Sliding Scale
or
Why Wages Are No Longer Indexed to Product Prices

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Abstract

There were many employment agreements linking wage rates to product prices, known as sliding scales, in Britain and the United States from the 1860s through the 1930s. They disappeared after the 1930s, despite the spread of long-term union contracts in the United States and the introduction of published wholesale price indices that gave workers new information about product price and materials cost. This paper explains why sliding scales disappeared after the 1930s, and examines what historical experiments with sliding scales reveal about the fundamental constraints on wage indexation.
Many theoretical models of long-term labor contracts (for example Blanchard, 1979; Hall and Lazear, 1984; Card, 1986; Oswald, 1986) imply that workers with bargaining power over an employer have incentives to index their wages to prices of the employer’s products, or to product prices less costs of variable inputs other than labor such as materials. Linking wages to product prices can effectively condition labor cost on the state of demand for the workers’ product. This tends to stabilize profit, creating a gain to a risk-averse employer that may be shared with workers through higher base wages. Even if employers are risk-neutral, there may be large gains to product-price indexation under realistic conditions. For whatever reason, most labor contracts appear to set above-market wage rates and leave the employer to choose employment levels (Farber, 1986). Within such a contract, product-price indexation would help prevent inefficient layoffs (or short-time) in the event that the value of a worker’s product in the enterprise is extraordinarily low but still higher than the prospective value of his next-best activity. Thus, product-price indexation can stabilize employment and increase the total expected value of the employment relation, with potential gains to both sides. Importantly, these incentives to product-price indexation can be strong whether or not wages are also indexed to consumption-good prices or the general price level. They are independent of any external benefits that would result from widespread wage indexation to product prices, such as damping real effects of monetary shocks (emphasized by Weitzman, 1984).

In reality, almost no North American union contracts have linked wages to product prices. Very rare exceptions include union contracts with the Magma Copper Company, which linked hourly wages to copper prices, along with the CPI, through 1992 (Charlier 1991, 1992), and 1990s union contracts with Inco, a Canadian nickel producer, which linked wages to the spot price of nickel (Bagnell, 1997).
cheaper to evaluate and implement when they are defined by a few simple numbers rather than functions” (Azariadis and Stiglitz, 1983, p. 17). However, no study has attempted to identify the special costs and information problems that product-price indexation would involve. There is no direct evidence that they are widespread - indeed ubiquitous - across industries with various technologies and product-market structures. Such evidence would be useful not only in understanding union contracts, which once governed a large portion of U.S. employment, but for current issues in macroeconomic theory. Many models in the burgeoning “new Keynesian” literature assume that workers have power in labor markets, employment has contract-like features, and wages are indexed to aggregate variables only (for example Erceg, Henderson and Levin, 2000; Christiano, Eichenbaum and Evans, 2005). Such assumptions might appear dubious if product-price indexation were common in union contracts.

In fact, before the 1940s, many agreements between unions and employers did link wage rates to product prices. They were generally referred to as “sliding scales.” The best-known sliding scales appeared in the British mining and metals industries before the First World War. These have attracted some attention in modern economics literature, usually in the context of long-term contract theory (Hall and Lazear, 1984, p. 255; Weitzman, 1984 pp. 78-79, 86; Card 1986 pp. s145, s150; Treble, 1987; South, 1990). However, as I will detail below, sliding scales were also common in U.S. mining and metals, and they were tried in other industries. In both countries, sliding scales attracted the favorable attention of economists and labor-relations officials. Alfred Marshall, A.C. Pigou, and Carroll Wright recommended their use wherever product prices and materials costs could be well defined (Massachusetts Bureau of Statistics of Labor, 1881, p. 74; Marshall [quoted in Price, 1887a, p. 84]; Munro, 1885, p. 26; Pigou, 1905, p. 104; 1927, p. 287). It was noted that the general adoption of sliding scales would speed the adjustment of wages to monetary shocks (Price, 1887a, p. 66). Unions and employers continued to negotiate sliding scales and similar schemes through the 1930s. After that, sliding scales disappeared.
From the point of view of labor-contract theory, the existence of sliding scales before the 1940s raises a number of questions. Viewed as experiments, what did they reveal about the costs and information requirements of product-price indexation? Why did sliding scales disappear after the 1930s? Can one really argue that special costs and information problems have blocked the use of product-price indexation in all industries since the 1940s, given that unions and employers used sliding scales in some industries through the 1930s?

The disappearance of sliding scales from the U.S. is especially puzzling. America saw two institutional developments which could have been expected to promote the use of sliding scales. Starting in the late 1930s, many formerly nonunion establishments began to bargain with unions, and union contracts with terms as long as three years became common (Freeman, 1998). In the early 1950s, workers gained new sources of information about product prices and materials cost, as the Bureau of Labor Statistics began to publish more timely, industry-specific indexes of wholesale (or producer) prices for a wide range of manufactured goods and raw materials (Hanes, 2006, p. III-153). WPI (PPI) series have been used to index a variety of long-term contracts other than wage agreements (Stigler and Kindahl, 1970, p. 15; U.S. BLS, 1991).

In this paper, I explain why sliding scales disappeared after the 1930s and examine what their history reveals about fundamental constraints on wage indexation. To begin, I describe the scope and structure of sliding scales, which point to a simple explanation for their disappearance from Britain and a more complicated explanation for the U.S. case. I argue that, paradoxically, the introduction of long-term union contracts actually reduced incentives to link wages to product prices. Pre-1940s sliding scales were not examples of long-term contract indexation in the sense of modern theory, but rather devices to forestall costly strikes in the absence of contracts, by revealing employers’ private information about product demand. To show that sliding scales can play this role, I present a model based on asymmetric-information strike models such as Hayes (1984) and Hart (1989). The model shows that the potential benefits of linking wages to product prices can be
smaller if unions are able to enter binding long-term contracts. Thus unions and employers were willing to adopt sliding scales in the pre-1940s U.S. and Britain, but not in the postwar U.S. where binding union contracts had become an option.

After presenting this argument, I show that its distinctive implications are consistent with available historical evidence. Finally, I examine statements of contemporary observers to discover the costs and information problems that arose in practice with sliding scales, and reasons that proposed sliding scales were rejected or abandoned after a trial. I find that workers’ price information was far from perfect even where outputs and nonlabor inputs were easy to define and there were observable open-market prices for products and materials. The specific features of product markets, nonlabor inputs and union organization that appear to have limited workers’ information were not resolved by the introduction of wholesale price indexes, and remain widespread today.

1. The general history of sliding scales

1.1 When and where sliding scales appeared

In Britain, sliding scales appeared in the ironmaking industry by the 1840s. By the 1880's they covered most skilled workers in iron, steel and tinplate, as well as many (perhaps most) iron-ore miners and coke production workers (Munro, 1885, 1889). In coalmining, sliding scales were common by the 1870s (Robinson, 1920, p.139). By the 1880s they covered about 120,000 coalminers (Munro, 1885, p. 1). In the 1890s many coalmining districts replaced explicit sliding scales with systems of arbitration by “conciliation boards,” but these boards effectively applied sliding scales (Pencavel, 1977, p. 142; Treble, 1987). Sliding scales were proposed at least once in the woolen textile industry, and on three separate occasions in cotton textiles, but not adopted (North, 1896; White, 1978, pp. 82-83).

After the First World War, many British union agreements linked wages to a consumer (“cost of living”) price index that the British government had begun to publish during the war (Great
Britain also adopted a generous and entirely unrated unemployment insurance scheme (Benjamin and Kochin, 1970), which presumably lowered the private cost of layoffs to workers and employers. But product-price sliding scales and similar schemes became even more common across the British mining and metals industries. As of 1925, they determined wages of about 220,000 men in metals, coke production, and iron ore mines (Great Britain Ministry of Labour, 1925, p. 269). Over the late 1920s and 1930s they were extended across more branches of the metals industries and to cover unskilled as well as skilled workers (Pool, 1938, p. 159). Coal unions and employers adopted a “proceeds-sharing” scheme that linked wages to “the difference between the proceeds from the sale of coal and the production costs other than labor” (Political and Economic Planning, 1936, p. 170).

In the United States, sliding scales appeared in ironmaking by the 1860s. By the 1880s they determined union workers’ wages in many steel plants and in most plants manufacturing iron rails, iron sheets or tin plate (Massachusetts Bureau of Statistics of Labor, 1881, p. 18; Ashley, 1903, p.154; American Iron and Steel Association, 1888, pp. 117, 297; U.S. Industrial Commission, 1901, p. 97). Over the 1900s, unions and their sliding scales were expelled from most of the U.S. iron and steel industry, but in the plants where unions hung on they continued to negotiate sliding scales through the early 1930s (Robinson, 1920; Daugherty, de Chazeau and Stratton, 1937, pp. 143-144).

In anthracite coal mining, sliding scales appeared by 1869, were used in some regions through the 1890s, and were adopted in an industry-wide arbitration decision in 1903 (Jeans, 1902, p. 19; Fisher, 1942, pp. 287-292). Sliding scales were common in zinc and silver mining, and copper mining, smelting and refining, through the 1930s (U.S. Bureau of Labor Statistics, 1914; U.S. Bureau of Labor Statistics, 1943; Greenfield, 1960, pp. 116-122), though they do not appear to have been used in bituminous coal (Tryon, 1921, p. 69).

Outside mining and metals, sliding scales were used in the U.S. glass industry in the 1880s and 1890s (Davis, 1949, pp. 132, 187; U.S. Industrial Commission, 1901, p. 136) and in the cotton
textile mills of Fall River, Massachusetts from 1905 through 1910 (Howard, 1920).

In both the U.S. and Britain, nearly all sliding scales were the result of bargaining or arbitration between unions and employers. In most cases the employer’s side was a trade association of firms in a regional industry. In many cases it is clear that the initial proposal of a sliding scale came from the union side (Robinson, 1920, p. 139-141; Sydenstricker, 1916, p. 14; Wright, 1893, p. 407; White, 1978, pp. 82-83). A few sliding scales were unilaterally adopted by employers in industries where other employers were negotiating sliding scales with unions (Munro, 1889, p. 132), or were retained by employers between spells of union activity (Roberts, 1901, p. 181).

1.2 The terms of typical sliding scale agreements

Sliding scale agreements specified piece or time-rates to be paid for jobs (examples of time rates include Munro, 1890, p. 148, 160; U.S. Industrial Commission, 1901, p. 96; Great Britain Ministry of Labour 1925, p. 270; U.S. Bureau of Labor Statistics, 1940, p. 15). Like the vast majority of pre-1930s union agreements (Seastone, 1955), they did not specify employment levels, lump-sum payments or payments to laid-off workers. Wages were readjusted periodically, at predetermined points in time, as a function of prices prevailing in the previous period.

Within this general framework, employers and union leaders devised a wide variety of indexing rules, apparently well-suited to dealing with imperfect price information and outside constraints on wage bargains. The relation between prices and wages could be continuous (for example U.S. Industrial Commission [1901, p. 89]) or a stepped schedule, so that prices had to range outside a step’s bounds in order to trigger a wage adjustment (Munro, 1885, p. 6, 10; Jeans, 1894, p. 63; Evans, 1909, p. 124). A given price change could trigger a bigger (Robinson, 1920, p. 146; Jeans, 1894, pp. 63, 65) or smaller (Munro, 1890) wage adjustment once prices rose above a threshold. Some agreements limited the magnitude of a wage change that could take place from any one period to the next, whatever the change in prices (Great Britain Ministry of Labour, 1925, p. 271). In some cases, the products whose prices determined a worker’s wages were not those of the
worker’s own establishment, but goods for which the worker’s product was an input (Munro, 1885, p. 8; Great Britain Ministry of Labour 1925, p. 272; Massachusetts Bureau of Statistics of Labor, 1881, p. 18).

It was generally recognized that a sliding scale had to account for changes in the cost of nonlabor inputs such as materials or transportation (Price, 1887a, p. 65), by *ad hoc* revisions to the wage-price schedule (e.g. Birkett, 1922, p. 157) or by including materials prices within the wagesetting formula. In many sliding scales, wages were not linked to the product price alone: they were instead linked to the “margin” between product prices and materials’ prices, with weights reflecting cost shares (Pool, 1938, p. 161-62; Lincoln, 1909; Bowie, 1927).

It was likewise recognized that wages in workers’ alternative employments placed a lower bound on a sliding scale wage (Munro, 1885, p. 25). Most sliding scale agreements set minimums below which wages could not fall; many set maximums too (Munro, 1890, p. 50; Massachusetts 1909, p. 259-260; Smart, 1895, p. 104; Jeans, 1894, p. 71; Price, 1898, p. 472; Carr and Taplin, 1962, p. 72; U.S. Industrial Commission, 1901, p. 135). There are no records of attempts to incorporate measures of outside wage rates into a scale’s formula, but unions and employers often agreed to revise a sliding scale in response to changes in outside wage rates (Smart, 1895, p. 74; Massachusetts, 1909, p. 267; Evans, 1909, p. 125). In at least one case, a union agreed to a downward ratchet of its scale because of an increase in outside unemployment (Price, 1887a, p. 41).

The sources of price information for some sliding scales were price lists that manufacturers circulated to customers (Price, 1887a, p. 58; Robinson, 1920, p. 146). Other sliding scales were based on published reports of open-market prices (U.S. Bureau of Labor Statistics, 1914, p. 137; Howard, 1920; U.S. Bureau of Labor Statistics, 1940, pp. 13-15; Robinson, 1920, p. 148). But many sliding scales - apparently, *most* agreements in coalmining and the metals industries - took prices from employers’ account books. In some cases the books were jointly examined by firm managers and union representatives (U.S. Bureau of Labor, 1904, pp. 237-238). More often, professional
accountants were hired to inspect the books: an accounting firm “approved by both parties” (Jeans, 1898, p. 85) or by an arbitration board (Price, 1887a, p. 45), or one accountant hired and paid by the union working alongside another hired by employers (Munro, 1885, p. 35; Great Britain Ministry of Labour 1925, pp. 270-272; Jeans 1894, p. 78; Smart, 1895, p. 66). When there were a number of firms on the employers’ side of an agreement, wages paid by all firms were based on the same price figure, an average across firms. If there were many firms, accountants might examine books from just a sample of them (Munro, 1890, p. 142; Jeans, 1894, p. 78, 85; Roberts, 1901, p. 177; Great Britain Ministry of Labour 1925, pp. 270).

### 1.3 The disappearance of sliding scales

In the British mining and metals industries, product-price sliding scales were suspended (or made ineffective) at the beginning of the Second World War, with the imposition of general economic planning controls (Haynes, 1953, p. 26; Burn, 1961, p. 27). They were not revived after the war. For this, there is a simple explanation. From the late 1940s through the 1970s, unionized mining and metals enterprises remained under various forms of government control over product prices, wages and employment levels, including periods of outright government ownership. Arguably, these controls broke the links between product prices, labor demand and wage bargaining that would form the basis of a product-price sliding scale. By the 1970s unionized coal mines and

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2 Coal mines were nationalized in 1947. In the 1950's, it was observed that the board regulating the industry “clearly does not aim to maximize profit” (Alexander, 1956, p. 165), as “Nobody disputes that the existing output of coal could be sold at a higher price” (p. 174), while union leaders limited bargaining demands to maintain “the stability of political institutions in general and of the public corporation type of nationalization of coal-mining in particular” (p. 166). The iron and steel industry was under private ownership over most of the 1950's, following an aborted nationalization at the beginning of the decade, but “As maximum prices were set by the Iron and Steel board for most categories of steel products the producers were unable to raise their prices” (Blair, 1997, p. 573). After the industry was nationalized again in the 1960's it was “a participant in various counter-inflationary programmes as steel prices were subject to restraint by the government..not able to operate freely in the market..under political pressure not to declare redundancies [layoffs].refused permission to increase its selling prices ” (p. 575, 576).
metals manufacturers were supported by public subsidies, and employed workforces far larger than any profit-maximizing enterprise would choose (Pryke, 1981, pp. 48, 59, 183-188). In the 1980s public subsidies were stopped and the unionized industries simply ceased to exist (Fraser, 1999, pp.235-36, 241-242).

For the United States, there is no such simple explanation for sliding scales’ disappearance. Unions returned to the U.S. iron and steel over the late 1930s, and gained bargaining power in many industries where they had never been effective before (Freeman, 1998). Outside wartime, the mining and metals industries were (largely) free of government control. But there was no revival of sliding scales in metals, and they became extremely rare in mining. In 1940, the United States Bureau of Labor Statistics found that “Plans for the automatic adjustment of wages to the price of the commodity produced are rare except in nonferrous metal mining and smelting” (U.S. Bureau of Labor Statistics, 1940, p. 13). In 1951, the BLS observed that even in nonferrous metals “the general practice of gearing wages to prices declined appreciably in the early 1940's” and did not reappear after the war (U.S. BLS, 1951, p. 49).

2. Sliding scales were not long-term contracts

To explain the disappearance of sliding scales from the U.S., it is important to recognize that no pre-1940s sliding scale agreement was a binding contract. Before the 1930s, courts did not recognize union agreements as legally enforceable contracts in either the U.S. or Britain. No government agency punished a union for going on strike, or punished an employer for locking out union members, in violation of a written agreement. As far as the state was concerned, employees were equally free (or equally forbidden) to strike whether or not they had a written agreement with the employer (Tomlins, 2000, 659-687). Reputational concerns may have discouraged some unions from striking in violation of an agreement (e.g. Arnot, 1949, p. 135; Robinson, 1920, p. 149; Price, 1887a, p. 46). But it is easy to find examples of unions abandoning agreements and going on strike before the end of an agreed-upon duration (for example Fisher 1942, p. 283; Read, 1894, p. 334;
Some scales have been described as being in effect for many years, but these were actually re-negotiated from time to time. What held over was some element of the relation between wages and product prices: see for example Carr and Taplin (1962, pp. 72, 139, 278).

Jeans, 1894, p. 53). Many sliding scale agreements specified no duration at all: either party could withdraw after a few weeks’ notice, not under pre-specified conditions as in modern labor contracts with “re-opener” clauses (Danziger, 1995), but at any time, for any reason (Massachusetts Bureau of Statistics of Labor, 1881, p. 16; Munro 1885, p. 18; Massachusetts Bureau of Labor, 1908, p. 264; Robinson, 1920, p. 148; Wright, 1893, p. 408). When a duration was specified, it was very rarely longer than one year.

In the United States (but not Britain [Shackleton, 1998]), union agreements took on enforceable status beginning in the late 1930s as a result of the Wagner Act of 1935, the Taft-Hartley Act of 1947 and related court decisions. A union that strikes in violation of a contract recognized by the National Labor Relations Board (NLRB) faces significant legal penalties (Mills and Brown, 1950, pp. 470-513). Contracts with terms as long as three years became the norm between unions and employers in most industries, including mining and metals (Taylor, 1983, Table 5). According to Garbarino (1962), after the Second World War “the underlying goal of bargaining strategy...was to minimize industrial strife by negotiating long-term contracts...a multi-year contract without periodic reopenings” (p. 10), “to avoid repeated negotiations and potential strikes” (p. 81). Contracts with liberal re-opener clauses became extremely rare (p. 117).

In theory, an employment contract that determines terms of employment and prohibits strikes for a fixed duration can mitigate “hold-up” problems (Williamson, 1985) that would otherwise cripple a unionized enterprise: if the union is free to extract the highest possible wages after the employer has incurred sunk costs, the employer will refrain from some investments that could increase both wages and profit. The wage gain resulting from greater investment ex ante can be enough to persuade union workers to enter a long-term contract, even though the contract prevents

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them from extracting the highest possible wages *ex post* (Grout, 1984). In fact, this appears to have been an important reason unions and employers entered three-year contracts in the postwar NLRB system. For example, in the late 1950s, steel manufacturers “had underway a substantial program of long-range capital investment and desired to avoid strikes as well as wide fluctuation of production and prices while the program was being effectuated” (Livernash, 1961, p. 295); a three-year contract allowed the industry to “go ahead with its expansion and modernization program without fear of industrial warfare” (p. 299).

In the postwar U.S., the addition of sliding-scale provisions to a union employment agreement would involve the issues highlighted by theoretical models of long-term labor contracts. The alternative to a sliding-scale contract is a long-term contract that simply fixes wage rates in terms of money or a general price level. Relative to this alternative, the potential benefits of a sliding scale are stabilized profits and avoidance of inefficient layoffs. These benefits are limited by the quality of workers’ information about product prices and materials cost. They must be weighed against any extra administrative costs of product-price indexation.

In the pre-1940s U.S. and Britain, long-term contracts of any form were not an option in bargaining between unions and employers. What was the role of a sliding scale in this setting?

### 3. A model of sliding scales outside contracts

#### 3.1 Overview

In this section of the paper, I present a model that illustrates a possible role for sliding scales outside binding long-term contracts. An important implication of the model is that unions and employers are more likely to adopt sliding scales when they cannot enter long-term binding contracts. Thus, the model can help explain why some unions and employers in some industries adopted sliding scales in the pre-1940s U.S. and Britain, but not in the postwar U.S.

The model has two key sets of assumptions. The first is that employers have better information than workers have about the current state of product demand, and that this distribution
of information results in strikes if workers and employers bargain over wage rates that are fixed in terms of money or a general price level. Here I follow “asymmetric-information” models of union bargaining such as Hayes (1984), Hart (1989) and Cramton and Tracy (1992). These show that costly strikes can occur as part of optimal bargaining strategies if at least one side has private information about the value of the employment transaction. For an employer, strike costs are worth paying in order to press down wages when the value of the union’s labor is relatively low. For a union, strikes are a necessary part of “a mechanism that allows workers to extract higher wages from more profitable employers” (Card, 1990). In effect, strike strategies serve to adjust the terms of employment to privately-observed variables. For my model I make the simplest possible assumptions along these lines: thus there are only two possible states with respect to labor’s marginal value product in the enterprise, and the union proposes employment terms which the other side can accept or reject (a “screening” model in Kennan and Wilson’s terms [1990]) subject to a threat that the union will strike for an interval of time (on this see Hart [1989]).

The second key assumption is that production requires a sunk input, which generates a potential hold-up problem. I refer to this sunk input as “capital,” but it should be clear that it need not correspond to structures and equipment; it can be any costly, irrevocable commitment to the enterprise that affects the marginal revenue product of labor. As a result of the hold-up problem, unions and employers would be willing, if they could, to enter long-term fixed-wage contracts rather than remain in a state of unconstrained bargaining subject to strikes. The ubiquity of long-term contracts among unionized establishments in the postwar U.S. indicates that this is a realistic condition for most industries, certainly for the mining and metals industries.

Other assumptions are chosen to match features of historical sliding scales described above. The employers’ side is a trade association of firms that compete with each other in the product market; an assumption that it is a cartel or product-market monopolist is more complicated but gives
similar results. I rule out agreements that specify employment levels or fixed payments to the union, and derive the union’s behavior from an individual member’s maximization of expected earnings subject to a predetermined layoff order and voting rule (on these points see Farber [1986]).

In the text, I lay out the model’s assumptions and relevant results. An appendix gives details.

3.2 General assumptions and notation

A union faces a set of many identical profit-maximizing, risk-neutral firms producing a homogenous, nonstorable good. Time is divided into three periods. In period zero a firm chooses the quantity of capital $K$ subject to a per-unit required expected return $R$. In each of the following two periods - period one and period two - a firm’s capital stock remains fixed while it can produce output $Y$ from labor $L$ and a raw material $X$, such that one unit of output requires one unit of the raw material. In addition to any costs of labor and materials, a firm is subject to a fixed operating cost $\Omega$ every period in which production takes place. Labor can be hired from the set of workers belonging to the union, or on an open competitive market at a going wage $W$ per period. If a firm does not hire from the union, effective labor input is lower (perhaps because union members have special skills, or because they are incumbents and it is costly to bring new workers into a firms' plants). Thus, a firm’s production function is:

\[ Y = \min(X, K^{\Theta} L^{\Lambda}) \quad \text{where} \quad \Lambda + \Theta < 1 \]  

with the union, but:

\[ Y = \min(X, K^{\Theta} (L/\Phi)^{\Lambda}) \quad \text{where} \quad \Phi > 1 \]

\[ 4 \] Results are similar as long as short-run marginal cost is increasing and the firm’s price markup over marginal cost is constant or increasing with the firm’s output. They are more complicated in that the sliding scale has an extra advantage extensively discussed by Weitzman (1984): because a sliding scale makes the marginal cost of labor to the firm a decreasing function of employment, it allows the union to engage in a form of price-discrimination that improves the available combinations of wages and employment. This extra advantage applies with or without contracts, so it does not affect my argument.
without the union. This means it is cheaper to produce with a union workforce as long as the per-worker cost of union labor does not exceed \( W \Phi \). The quantity of each firm’s output demanded in a period is:

\[
Y^D = \left( \frac{D}{P} \right)^\Gamma \quad \text{where} \quad \Gamma > 1
\]

where \( P \) is the price of the homogenous good - the same for all firms in the industry - and \( D \) is an exogenous demand variable. \( M \) represents the cost of the raw material relative to the product price \( P \), where \( M < 1 \). In period zero, the values of \( D \) and \( M \) are uncertain. They are realized in period one and remain the same through period two.

The variables representing product demand, prices, wages and required returns (\( D, P, W \) and \( R \)) can be assumed to be denominated in money or relative to a general price level, such as the price level for consumption goods. Under the latter assumption, “fixed wages” as described below correspond to wages indexed to the general price level only; “sliding-scale” wages would be indexed to product price and the general price level.

Union members can coordinate their behavior in a limited way: they cannot enforce transfers of income between members or prevent a member from leaving the union to take employment on the outside labor market, but they can make a common demand of employment conditions to the firms in the industry, and withdraw their labor for a period - go on strike - if the firms do not accept this demand. If the firms accept the union's demand but choose to employ fewer workers than the number of union members, union members are laid off in a predetermined order (for example, by seniority). Any union action must be approved by a number \( N \) of members, and each member acts to maximize the expected value of his labor income. Thus, the union will act to maximize the \( N \)th member’s expected labor income. The particular identity of the \( N \)th member depends on the union’s decision-making rules. If the union follows majority rule, the \( N \)th member is the median member in the lay-off line. If the union acts by consensus, the \( N \)th member is the marginal member - the first to
be fired. I need not be specific here.

The industry’s firms cannot collude in sales or capital investment, but they can respond to the union’s demands as a group to maximize expected profit. If they reject the union’s demand, they can immediately replace the union workforce with new workers hired from the outside labor market, in which case they pay the going wage \( W \) and produce according to expression (2) while union members take other jobs at the going wage. Alternatively, the firms can wait out a strike to receive another offer from the union. During a strike, union members receive no labor income; the firms' plants are closed, producing no output and incurring no costs other than the required return to capital, but losing the period’s potential sales.

What would happen if the union demanded, and firms accepted, a fixed wage \( W \) in period one or two? Setting marginal cost defined by (1) equal to the price in (3) gives output per firm. Corresponding values for the product price and employment per firm are:

\[
P(W, Z, K) = \left[ \Lambda^{-\Lambda} K^{-\Theta} Z^{(1-\Lambda)} W^\Lambda \right]^{1/(1-\Lambda)}
\]

\[
L(W, Z, K) = \left[ \Lambda^\Gamma K^{(\Gamma-1)\Theta} \left\{Z/W\right\}^\Gamma \right]^{1/(1-\Lambda)} \quad \text{where} \quad Z = D \left(1-M\right)^{\Gamma-1}
\]

Employment depends on the wage and the capital stock, and on a variable \( Z \) which summarizes the effects of product demand and materials cost. The joint distribution of \( D \) and \( M \) is such that \( Z \) takes either a high value \( Z_H \) or a low value \( Z_L \). One could assume, for example, that product demand takes either a high or low value, while low product demand is sometimes offset by low materials cost. As of period zero, the probability that \( Z \) will turn out to be low is \( \Pi \).

If workers could observe the realized value of \( Z \), the union would always demand the highest wage that allows for employment of the \( N \)th member, taking the capital stock as given. That wage is defined by setting \( L(W, Z, K) \) in (5) equal to \( N \) divided by the number of firms, as long as the result
is greater than a lower bound $W$ (the outside going wage) and less than an upper bound $W \Phi$ (the wage that makes it cheaper for the firms to hire replacement workers); otherwise the wage is simply equal to one of the bounds. To simplify notation, we can scale variables to $N$ and the number of firms such that the $N$th member is employed as long as $L \geq 1$. Thus, if $Z$ is high the union’s wage demand would be:

$$W_H(K) = \Lambda K^{(r-1) \Theta} Z_H \quad \text{for} \quad \Lambda K^{(r-1) \Theta} Z_H \leq W \Phi$$

$$W_H(K) = W \Phi \quad \text{otherwise}$$

If $Z$ is low:

$$W_L(K) = \Lambda K^{(r-1) \Theta} Z_L \quad \text{for} \quad \Lambda K^{(r-1) \Theta} Z_L \geq W$$

$$W_L(K) = W \quad \text{otherwise}$$

Assume, however, that the realized value of $Z$ is observed only by the firms, not by workers.

### 3.3 Fixed wage rates and strikes in the absence of contracts

What happens if the union cannot bind its future behavior in a contract and the two sides negotiate over fixed wage rates? In this case, the union strategy that maximizes the $N$th member’s expected income may result in strikes, as follows. In period one, taking as given the capital stock firms installed in period zero, the union demands $W_H(K)$: this is the highest wage that allows for employment of the $N$th member assuming $Z$ is high. If $Z$ is indeed high, the firms accept this demand; in the second period the union makes the same demand and the firms again accept it. If $Z$ is low the firms reject the union’s first demand but refrain from replacing the union workforce: thus there is a strike. After a strike, in the second period the union cuts the wage demand down to $W_L(K)$, which the firms accept. Back in period zero, looking forward to these wage demands and the
probability of a strike, each firm sets $K$ equal to the value $K_{STR}$ which equates the required return $R$ to the expected value of the marginal product of capital. Thus:

$$K_{STR} = \left( \Lambda^{(\Gamma-1)} \left( \frac{\theta}{\Theta} \right)^{\Lambda+\Gamma(1-\Lambda)} \left[ (1-\Pi)Z_H^\Gamma W_H(K_{STR})^{-\Lambda(\Gamma-1)} + \frac{\Pi}{2} Z_L^\Gamma W_L(K_{STR})^{-\Lambda(\Gamma-1)} \right] \right)^{\frac{1}{\theta+\Lambda+\Gamma(1-\theta-\Lambda)}} \tag{8}$$

Expressions (6), (7) and (8) together define $W_H(K_{STR}), W_L(K_{STR})$ and $K_{STR}$. (Depending on parameter values, both the high and low wages may be within the bounds given by $W$ and $\Phi W$, or one of the wages may be at a bound.) A union member’s expected labor income per period is:

$$I_{STR} = (1-\Pi)W_H(K_{STR}) + \frac{\Pi}{2} W_L(K_{STR}) \tag{9}$$

The alternative strategy for the union is to offer the low wage $W_L(K_{STR})$ immediately in the first period. A wage anywhere between $W_H(K_{STR})$ and $W_L(K_{STR})$ is out of the question, because it would not gain the $N$th member first-period employment if $Z$ is low, and would give him income lower than $W_H(K_{STR})$ if $Z$ is high. For a range of values of the model’s parameters (see the appendix), $I_{STR}$ is greater than $W_L(K_{STR})$. Hence, the union follows the strike strategy.

### 3.4 Fixed-wage contracts

Now assume that in period zero the union can offer the firms a binding contract that specifies wage rates for periods one and two. If the firms accept, the union cannot strike. If the firms reject the contract, the union reverts to the series of wage demands described above. A fixed-wage contract that firms would accept, and that may promise the $N$th member expected earnings greater than $I_{STR}$, is a contract that fixes the wage for both periods at $W_L(K)$, that is, the highest wage that allows employment of the $N$th member if $Z$ is low. Back in period zero, with the contract in hand, firms set $K$ at the value that satisfies:

$$K_{CON} = \left( \Lambda^{(\Gamma-1)} \left( \frac{\theta}{\Theta} \right)^{\Lambda+\Gamma(1-\Lambda)} \left[ (1-\Pi)Z_H^\Gamma W_L(K_{CON})^{-\Lambda(\Gamma-1)} + \Pi Z_L^\Gamma W_L(K_{CON})^{-\Lambda(\Gamma-1)} \right] \right)^{\frac{1}{\theta+\Lambda+\Gamma(1-\theta-\Lambda)}} \tag{10}$$
Expressions (7) and (10) together determine $K_{CON}$ such that $K_{CON} > K_{STR}$. A contract attracts more investment because it prevents strikes when $Z$ is low and also prevents the union from extracting a higher wage when $Z$ is high. Because $K_{CON} > K_{STR}$, for a range of parameter values (again, see the appendix) it is the case that $W_I(K_{CON}) > I^{e}_{STR}$: the $N$th member’s wage under the long-term contract exceeds his expected wage income outside a contract, subject to strikes. Thus, the union and employers are willing to enter a long-term fixed-wage contract that prohibits strikes, even though they would follow strategies that would result in strikes outside a contract.

3.5 Sliding scales

Now suppose the materials cost is a market price $P_M = MP$; the workers can observe both $P_M$ and the product price $P$; and the wage can be specified as a function of $P$ and $P_M$, but only at a fixed per-worker cost equal to $C$ per period.

**Sliding scale contracts**

Assuming that the union can also enter binding contracts, in period zero the members can offer the firms a contract that will set the wage for each future period as a function of future product and material prices. The contract that maximizes the $N$th member’s expected earnings, and that the firms would accept over bargaining without a contract, is:

$$W_{SS} = \begin{cases} \Lambda K^{\Theta} (P - P_M) & \text{for} & W \leq \Lambda K^{\Theta} (P - P_M) \leq W \Phi \\ W & \text{for} & \Lambda K^{\Theta} (P - P_M) < W \\ W \Phi & \text{for} & \Lambda K^{\Theta} (P - P_M) > W \Phi \end{cases}$$

(11)

Note that (11) matches the form of many historical sliding scales: between a minimum and

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5This is the only fixed-wage contract that the firms will accept and that can possibly offer the $N$th member expected earnings greater than $I^{e}_{STR}$, for any parameter values. The firms will not accept a contract wage greater than $W_I(K_{STR})$: better to go without a contract. The marginal union member cannot gain by offering a wage between $W_I(K_{STR})$ and $W_I(K_{CON})$: that would reduce his income in the event that $Z$ is high without gaining him first-period employment at low $Z$. 

---
maximum, the wage is scaled to the manufacturer’s margin \((P - P_M)\). Subject to this contract, each firm chooses the quantity of output and employment that equalizes the product price and marginal cost, taking as given the wage corresponding to that product price. Expressions (11) and (4) together determine the resulting product price and wage such that \(W_{SS}\) is equal to \(W_H(K)\) if \(Z\) is high, and equal to \(W_L(K)\) if \(Z\) is low. Back in period zero, firms choose a capital stock \(K_{SS}\) that satisfies:

\[
K_{SS} = \left( \Lambda^\Gamma - 1 \left( \frac{\Theta}{g} \right)^{\Lambda + \Gamma (1 - \Lambda)} \left( (1 - \Pi) Z_H W_H(K_{SS})^{-\Lambda (\Gamma - 1)} + \Pi Z_L W_L(K_{SS})^{-\Lambda (\Gamma - 1)} \right) \right)^{\frac{1}{\Theta + \Lambda - \Gamma (1 - \Theta - \Lambda)}}
\]

(12)

The member’s expected earnings per period before accounting for the extra indexing cost \(C\) is:

\[
I_{SS}^e = (1 - \Pi) W_H(K_{SS}) + \Pi W_L(K_{SS})
\]

(13)

For any parameter values, \(I_{SS}^e\) exceeds \(W_L(K_{CON})\): this sliding-scale contract must offer the \(N\)th member higher expected earnings than the fixed-wage contract. That is because the sliding scale automatically adjusts the wage to the \(N\)th member’s marginal revenue product, stabilizing industry employment at the level that just prevents his layoff. Among the set of possible fixed-wage contracts, the union can only choose between a low wage that ensures the \(N\)th member’s employment, and a high wage that creates a danger of layoff. Of course, the union must also take into account the fixed cost of product-price indexation \(C\). The union will offer the firms a sliding scale contract only if this cost is less than the benefit \(I_{SS}^e - W_L(K_{CON})\), that is the differential in expected earnings between a sliding scale contract and the fixed-wage contract.

What if the workers’ information about product price and materials cost is imperfect? If employers can manipulate the margin figure, the union certainly cannot offer a sliding scale: in the event that \(Z\) is high, employers would manipulate the figure to wrongly indicate the value corresponding to \(Z_L\), which would allow them to employ the same number of workers at the low wage \(W_L(K_{SS})\). If the workers’ information is simply noisy, so that it sometimes indicates a low
margin when \( Z \) is actually high and vice versa, the outcome under a sliding scale depends on further assumptions (about the role of laid-off members within the union, and the two sides’ ability to renegotiate a contract) to determine what happens if the \( N \)th member is laid off under a contract. Generally, however, the expected value of a sliding-scale contract to the member must be reduced. For any given value of \( C \), the union is more likely to stick with a fixed-wage contract. These points are no different from standard models of wage indexation, so I do not focus on them here.

**Sliding scales outside contracts**

What if the union cannot bind its future behavior in a contract? It can still offer employers a sliding scale, not as an element of a contract offered in period zero, but as a demand subject to a strike threat at the beginning of period one. Importantly, the outcome would be exactly the same as the sliding-scale contract just described. Taking the capital stock as given, the \( N \)th member’s expected earnings are maximized by the sliding scale defined by (11). The firms always accept the sliding-scale demand in the first period, even if \( Z \) is low: in that event the sliding scale delivers the same wage the union would offer following a strike, so the firms cannot gain by rejecting the union’s first demand. The union will demand the same sliding scale in the second period, even if the first period’s sliding-scale wage has revealed a high state of \( Z \): the member would only lose by demanding a wage higher than that delivered by the sliding scale.

Looking forward from period zero to these demands and the absence of strikes, firms install the capital stock \( K_{SS} \) defined by (12), and the \( N \)th member’s expected earnings are given by (13). The member’s gain in expected earnings over the outcomes of fixed-wage demands and strikes is:

\[
I_{SS}^e - I_{STR}^e = \frac{\Pi}{2} W_L(K_{STR}) + (1-\Pi)\{W_H(K_{SS}) - W_H(K_{STR})\} + \Pi\{W_L(K_{SS}) - W_L(K_{STR})\}
\] (14)

\( I_{SS}^e \) exceeds \( I_{STR}^e \) partly because the sliding scale results in a greater capital stock, and partly because it gives the workers the low wage rather than nothing in the first period in the event that \( Z \) is low. The union will offer a sliding scale if \( (I_{SS}^e - I_{STR}^e) \) exceeds the fixed cost \( C \).
As in the case of a sliding-scale contract, the potential benefit of a sliding scale outside contracts depends on the reliability of the workers’ margin figure: if it is too noisy or manipulable by employers, the union should stick with fixed-wage bargaining. However, a sliding scale is more likely to appear if the union cannot enter binding contracts, as long as the union would take a fixed-wage contract over no contract at all. Recall that $I_{STR}^e$ (expected earnings under continuous fixed-wage bargaining) must be less than $W_L(K_{CON})$ (earnings under a fixed-wage contract): otherwise, the union would be unwilling to sign a fixed-wage contract. Hence $(I_{SS}^e - I_{STR}^e)$ must be greater than $(I_{SS}^e - W_L(K_{CON}))$: the sliding scale’s expected earnings gain over continuous fixed-wage bargaining must be greater than its gain over a fixed-wage contract.

### 3.6 How the model accounts for the rise and fall of sliding scales

The model can account for the disappearance of sliding scales as follows, if one takes as given that sliding scales involved extra administrative or negotiation costs and that the quality of workers’ price information varied across industries. Sliding scales emerged in an era when long-term union contracts were not an option, in industries where unions bargained with profit-maximizing employers, employers’ private information about product demand would otherwise result in strikes, and workers had sufficient information about product price and materials cost. These conditions were often met in mining and the metals industries, but not elsewhere. After the 1930s, sliding scales disappeared from British mining and metals because the industries’ employers were no longer setting prices and bargaining over wages to maximize profit. In the U.S., sliding scales disappeared as the new NLRB system created the option of long-term fixed-wage contracts, which gained some of the potential benefits of sliding scales without incurring the extra costs.

### 4. Evidence from contemporary descriptions of sliding scales

Is there any evidence that pre-1940s sliding scales actually played the role illustrated by the model? What were the extra administrative or negotiating costs associated with sliding scales, and the factors that limited workers’ information about product prices and materials costs? Why were
these factors less of a problem in mining and the metals industries?

Unfortunately, history has left behind no systematic quantitative data relevant for these questions. Surviving pre-1930s data sets (such as those examined by Card and Olson [1995]) do not indicate which firms did and did not use sliding scales. The precise spans of time over which sliding scales operated cannot be identified for any meaningful sample of firms or industries.

There is, however, a wealth of relevant information in statements of contemporary observers and histories of the industries concerned. These describe why unions and employers adopted sliding scales, how sliding scale agreements were administered and the problems that arose with them in practice. For a few cases, contemporaries give specific reasons sliding scales were rejected when proposed, or abandoned after a trial. Particularly useful are the reports of special commissions on labor relations conducted by the British parliament in the early 1890s, and by the U.S. Congress around 1900. Both commissions frequently inquired about the use of sliding scales, and asked some witnesses why their industries did not use sliding scales. In the next sections of the paper, I draw on these sources to test the applicability of my model and to discover costs and information problems associated with sliding scales.

5. Why did pre-1940s unions and employers adopt sliding scales?

I have argued that sliding scales were adopted in order to forestall costly strikes by reproducing wage adjustments that could only occur following strikes if unions and employers haggled over fixed wage rates. Contemporary observers often discussed theoretical benefits of sliding scales in general, and sometimes described the origin of particular sliding scale agreements. Their statements are remarkably consistent with my argument.

According to nearly all contemporary observers, the main purpose of a sliding scale - usually the only one mentioned - was to reduce the frequency of strikes and lockouts, avoiding industrial “warfare,” promoting industrial “peace” (examples include Great Britain [1894, p. 41], Marshall [quoted in Price, 1895, p. 63], U.S. Industrial Commission [1901, p. 344], Price [1901, p. 239], Pool
[1938, p. 172]). Indeed, one objection to sliding scales expressed by union leaders was that “whilst the scale lasts, it renders the chief work of the union superfluous” (Great Britain, 1894, p. 43). In a discussion otherwise critical of sliding scales, Chapman (1903) judged that “sliding scales have succeeded..in doing that for which they were chiefly proposed, in making the process of distribution more peaceful” (p. 195). According to Munro (1885), sliding scales gave “a steadiness to trade; at least in so far as disputes between employers and employed tend to render trade unsteady” (p. 26). Making the same point, Robinson (1920) adds that “Employers will avail themselves of fresh openings with more vigorous enterprise, if freed from the apprehension of a sudden and forcible cessation of industry” (p. 157).

In all accounts of sliding scales’ origins, they are described as emerging out of strike-ridden bargaining or arbitration between unions and employers. It is clear that the alternative is not a binding arrangement fixing wage rates over a long term, but rather continuous haggling subject to strikes (examples include Wright, 1893; Roberts, 1901, p. 177; Davis, 1949, p. 132; Morris and Williams, 1960, pp. 160-163). Some accounts state explicitly that the purpose was to achieve the same wage adjustments that would occur anyway as a result of such continuous bargaining, but with less dispute. Jevons (1915) describes the development of the sliding scale in British coalmining:

During the nineteenth century, whenever a slump of trade set in, coal owners found the margin of profit being turned into a loss, and were forced to try and economise by reducing wages. More often than not this led to a strike, in which the men had to give way...The men, finding that they had to accept a reduction of wages from time to time, took care to agitate for an increase when trade improved, with the result that there were sometimes also strikes when trade was improving as well as when it was collapsing...

The frequency with which labour disturbances arose solely from the rise and fall of the market, led to a general desire to make some arrangement between masters and men which would allow for, and regulate, changes in wages in accordance with the state of trade.

After a good deal of local discussion, the idea of the Sliding Scale, in which wages varied automatically with the price of coal, took definite shape (p. 490).

Hicks (1930) describes the origin of one British metals scale in a similar way: a conciliation board was established to prevent strikes, and the board hit on sliding scales as a means to do so.
In an industry which is highly susceptible to the influence of the trade cycles changes in wages would be continually demanded, and the same reason would be put forward for the change, whether the demand came from employers or employed... The price of iron was pointed to by each side as an index of trade, and the boards found little difficulty in establishing the principle that wages should rise and fall with the price of the product. It was as short step from this to save argument by agreeing on a scale by which wages should change with prices... the scales added to the stability of the boards, by providing the industry with a principle of agreement on the matter about which the parties were most likely to differ (Hicks, 1930, p. 36-37).

According to Read (1894), sliding scales were adopted in South Wales coal fields at times when they were rejected in other coal regions because the peculiar market for South Wales coal made strikes especially costly (p. 332).

In a comparison between firms that did and did not use sliding scales, one would not necessarily expect to observe sliding scales associated with a lower frequency of strikes: presumably, unions and employers would be more likely to adopt sliding scales where other factors tended to make strikes more frequent. However, it was often claimed that the use of sliding scales tended to reduce strike frequency in an otherwise strike-prone industry, or that a particular sliding scale had effected wage cuts that would otherwise have taken place only after strikes (Jeans, 1894, p. 75; Price, 1887a, p. 79; Smart, 1895, p. 64; Birkett, 1922, p. 156; Pool, 1938, pp. 172-173; Webb and Webb, 1897, pp. 232-33). In Fall River textiles, unions and the manufacturers’ association agreed to their first sliding scale soon after the “Great Strike of 1904", when workers struck for nearly six months because employers had cut wages 12.5 percent following a prolonged decrease in product demand (Howard, 1920, p. 20). A sliding scale was in force when product demand fell again after the Panic of 1907.

The events of the next six months, ending in May 1908, illustrate best of all the chief benefit to be derived from a sliding scale of wages... the sullen preparations for resistance to an expected reduction of wages, which usually marked a sharply declining market, were entirely absent... When on May 25 the time again came for the semiannual adjustment of wages... it was found that [the scale] called for a reduction in wages... amounting to a general reduction in wages of all the workers of 17.94 per cent... The fact that the reduction was accepted without hesitation gives promise for the continued success of the experiment (Lincoln, 1909, p. 462-64).
6. Special costs and information problems associated with sliding scales

6.1 Negotiation and administration costs

Sliding scales required unions and employers to reach agreement on more figures than would be necessary if they were haggling over fixed wage rates. Even the simplest sliding scale involved not only minimum or base rates for each job, but a wage-price schedule or function consistent with the employers’ technology, nonlabor costs and product-demand conditions. In practice, the determination of an initial schedule for a newly-established sliding scale required the collection of historical information on wages and prices in the industry. According to the British Industrial Commission:

A sliding scale is usually based on an ascertainment from the books of an adequate number of employers of the net average selling price of the commodity which is to regulate the wages, such ascertainment being obtained for a series of recent years, the various rates of wages which have prevailed during the like period being also similarly ascertained. The relation in the past..(which relation had probably been brought about by free bargaining or, it might be, as the result of a strike or arbitration), being thus established, a scale is constructed of a character which, had it been in operating during the years taken as a guide, would, over that whole period, have yielded not less but probably rather higher earnings (Great Britain, 1894, p. 42).

In all three, unsuccessful attempts to establish sliding scales in British textiles, unions and employers quickly settled on measures of product prices and materials cost - “As margins were practically a matter of public knowledge, no cumbersome procedural apparatus would be required” (White, 1978, p. 80) - but could not agree on a functional relation between the margin and wages, partly because employers would not accept the recent relation between prices and wages as its basis.6

6 Employers demanded that the schedule be set to give an initial wage cut at the current value of the margin, while unions insisted that the scale be anchored at current values of wages and margins (Price, 1901, p. 241; White, 1978, pp. 82-83). In the 1899 negotiations, both sides agreed that the scale should be based to give employers a 5 percent rate of return on capital, but they could not agree on the corresponding value of the margin. The employers proposed to settle the question by examination of their books, but “the men appear to have felt, whether rightly or wrongly, suspicion of the trustworthiness of the books which would be examined” (Price, 1901, p. 241). The first (continued...)
Once a sliding scale was agreed to there were special costs of administering it. These are easy to observe in the case of scales that took prices from employers’ accounts. The professional accountants who were usually employed to examine the books had to be paid. In the American anthracite scale of 1903, the accountant was “named by one of the circuit judges of the third judicial circuit of the United States” but “paid by the coal operators, such compensation as the appointing judge may fix, which compensation shall be distributed among the operators in proportion to the tonnage of each mine.” According to Sydenstricker (1916), mine operators wanted to abandon this scale partly because “The cost of the elaborate of system of accounting..was heavy and had to be borne by the operators” (p. 34).

Apart from this comment, however, contemporaries did not cite administrative costs as a problem of sliding scales. In cases for which we know actual costs of accounting services, they appear negligible relative to labor costs or workers’ earnings. In British coalmining scales of the 1870s-1890s, accounting costs to the union side - presumably about equal to the employers’ costs - were covered by one or two pence per month (referred to as the “Sliding scale pence”) deducted from each miner’s pay (Webb and Webb, 1897, p.210-11; Arnot, 1949, p. 60-61). This was less than two-tenths of one percent of miners’ monthly earnings (around 5 pounds a month in 1881, over 7 pounds a month in 1901 [Williamson, 1980, p. 474]). There was also the clerical work of calculating the pay due an individual worker. But there is no reason to believe that sliding scales imposed many extra costs here. A worker’s time- or piece-rate earnings could be calculated at fixed base rates, then multiplied by the general sliding scale factor.7

6(...continued)
Fall River sliding scale was adopted soon after the publication of results from a state investigation of the relation between the margin and employers’ profits (Howard, 1920, pp. 20-21).

7In a British metals scale, a worker’s earnings were tallied at the base rate, then scaled “by adding or deducting the needful percentage at the foot of the pay tickets” (Munro, 1885, p. 11).
6.2 Information problems

In contrast to administration costs, information problems were a constant theme of contemporary accounts. One union leader told the British Industrial Commission that the sliding scale “does not apply in my trade [nuts and bolts] at all, because it is very difficult to get at the prices...Ours being a trade which embraces a great number of technicalities and specialities it is impossible for us to find out what price the employers get for them” (Great Britain, 1892, p. 471). In testimony to the U.S. Industrial Commission, a Massachusetts state labor arbitrator was asked:

Q. Do you think it is possible in the boot and shoe industry in the State to establish between the workmen and the employers...a sliding scale agreement, changable, say, in 90 days by the working committee on each side. Would that be more advantageous to the business in giving stability of employment to the men, and a perfect knowledge on the part of the employers as to what would be the cost of the goods and what they could market them for?

A. Theoretically, I should say yes; practically, I should have little expectation of anybody carrying it out in good faith...I can conceive of a shoe manufacturer meeting his workmen to make up a new list, as you say, on a sliding scale that would take into consideration the present cost of production and stock, but the first difficulty you would run against would be this, that the workmen would not believe a word of what the manufacturer said as to what his goods cost him or what he sold his goods for (U.S. Industrial Commission, 1901, p. 918).

Of course, actual sliding scales did not rely on employers’ bare statements about product prices and materials cost. They were based on list prices, open-market prices, or prices taken from employers’ account books. However, each of these types of price information was subject to problems.

List prices

List prices could differ substantially from prices received by employers because actual sales were subject to special discounts or premiums. The relation between list prices and effective sale prices was obviously subject to employers’ control. The first scales in ironmaking were based on list or “card” prices set by manufacturers’ associations and circulated to customers. But in the U.S., “This scheme caused considerable friction, because iron was frequently reported to be selling above
the card rate” (Robinson, 1920, p. 146). In Britain “in practice the list prices were not effectively binding upon members of the Association, and the prices of ordinary merchant bars (by far the highest proportion of the trade) varied considerably both from the list price and between firm and firm” (Carr and Taplin, 1962, p. 64; see also Price, 1887a, p. 58). The president of a glassworkers’ union told the U.S. commission that his union had tried sliding scales but preferred fixed wage rates because:

The sliding-scale system must be based now on certain rebates and discounts that you can hardly find out. You must depend a great deal on the honesty and integrity of the manufacturers. It is hard to reach. They have an understanding among themselves that they will sell a certain amount of glass to a dealer, and if he buys so much he will get a certain rebate.
Q... And they do not like to expose that to their men to see what they are making?

Open-market prices

By the 1890s, business newspapers and trade journals in both the U.S. and Britain (such as the Iron and Coal Trades Review and the Economist in Britain, the Engineering and Mining Journal and the Journal of Commerce in the U.S.) were publishing frequent, regular reports of open-market spot prices for many minerals, industrial raw materials, and standard manufactured products. These prices appear to have represented prices in actual transactions. It was observed, however, that open-market prices could differ from prices actually received by employers (Jeans, 1894, p. 79). Open-market prices were necessarily those for an industry’s most standardized products, which need not be well-correlated with prices for specialized products. Most sales could be subject to long-term contracts, despite the existence of spot transactions for the same products. On the materials side, spot prices could differ from actual materials cost simply because employers could hold stocks. All of these problems arose in the relatively well-documented experiments with sliding scales in the cotton textile mills of Fall River, Massachusetts.

At first glance, the cotton textile industry appears to have been well-suited to sliding scales. Raw cotton was the only important material: it represented about 90 percent of nonlabor variable
costs (International Cotton Bulletin, 1927). Business newspapers published regular, frequent reports of open-market prices for various types of cotton and standard textile products (in the U.S., specific types of cloth). Within cotton textiles, the Fall River industry was especially well-suited to sliding scales as it was “the center of the plain rather than of the fine goods manufacture... products are less diversified than elsewhere” (Howard, 1920, p. 14).

The first Fall River scale, adopted in October 1905, called for wage rates to be adjusted once a week, subject to minimums, as a nearly-continuous function of the margin between prices for two standard cloth types and the quantity of raw cotton required to make those types. Price figures were weekly averages of price quotes published daily in the Journal of Commerce (Massachusetts, 1906, p. 195). According to a local observer, some workers began to object to this scheme as they came to doubt that these open-market prices for standard cloth types were closely correlated with prices for the mills’ specialized products and goods sold on contract. Also, the manufacturers’ materials cost was not the same as the spot price of cotton:

an advance in the price of cotton did not mean an increase in the cost of manufacturing unless the agents actually bought cotton at the higher price, and that a reduction in the price of cloth by 1-16th a cent per yard did not mean smaller profits, unless goods were actually sold at the lower price. The mills had been stocked with cotton, so that it was unnecessary to buy at the higher quotation. A large part of the goods produced by the mills consisted of fabrics other than print cloth, the prices of which were in no way regulated by the price of prints; and even if they were, the goods had been sold ahead at a higher price (Lincoln, 1909, p. 458).

In fact, mill operators did actively manage stocks of raw cotton and time their purchases to minimize materials cost, in response to somewhat-predictable variations in spot prices (Stanwood, 1913, p. 372). Though standard products were relatively important in Fall River, they still represented “probably less than one-third of the product...the main product being ‘fancies’ and ‘odds’ Under the present system a fall in the price of print goods would lower wages, even though the mill was not running on prints at all and indeed it might be making a large profit on fancies” (Massachusetts, 1906, p. 195-196). In June 1906, this sliding scale was abandoned and replaced with fixed wage
rates “at the request of the textile unions” (Massachusetts 1908, p. 259).

In May 1907 unions agreed to another sliding scale after “The margin..was found to have widened quite substantially, and the advantages which might have accrued to the operatives had they not insisted upon abandonment of the sliding scale appeared great” (Howard, 1920, p. 25). This scale based wages on the same set of prices but was a stepped schedule; wages remained fixed as long as the margin remained within five-cent bands, and were adjusted only “in May and November of each year..based on the average margin between the cost of the raw material and the price of the finished product for the previous six months...thereby avoiding the weekly fluctuations which were found unsatisfactory under the old system” (Massachusetts 1908, p. 259-60). However, it was still the case that “because of the speculative element in the cotton market the existing method of figuring the margin was not considered to be a fair one” by some on the unions’ side (p. 262).

There is not much object in averaging raw cotton prices for a week or even for six months with a view to determining wages unless it is known that the cotton used in production was actually bought at the prices averaged. Examination of commercial statistics shows that by far the heaviest buying of cotton stocks by mills..is in the months of October, November, December and January of each year...It is evident that any system of basing wages on margins averaged for six-month periods ending in May and November does not fairly allow for the uneven distribution of cotton purchases throughout the year. And yet an adjustment of the dates of margin and wage calculations to meet this seasonal fluctuation is not easy for the fluctuation is not regular (Howard, 1920, p. 35-36).

Consistent with this argument, when the manufacturers waived their rights to a wage cut in November, 1908, they “explained that supplies of cotton were secured much below recent quotations; had the manufacturers been forced to buy raw materials and sell products at current quotations, the waiving of the rights would not have been possible” (p. 28). In 1910, the unions and employers again reverted to negotiation over fixed wage rates. They never again tried a sliding scale.

*Prices taken from employers’ accounts*

Most sliding scales in coalmining and the metals industries appear to have taken prices from employers’ account books, even though open-market prices for many standard metal products and coal of various types, in a variety of geographic locations, could be found in business publications.
For example, in U.S. metals around 1900, union agreements linked wages of ironworkers producing a variety of products to the price of bar iron alone, and all tinworkers’ wages to the price of one standard type of tin plate. The Journal of Commerce reported open-market prices for both products on a regular basis, but the scales took prices from employers’ books (U.S. Bureau of Labor, 1904, pp. 237-238).

Employers’ accounts could show terms of actual sales transactions, net of discounts or premiums (e.g. Price, 1887a, p. 45). On the other hand, “the time occupied in the clerical work of abstracting, compiling, and checking” (Evans, 1909, p. 128) the accounts meant that wages could not be adjusted very frequently (Bowie, 1927, p. 387; Munro, 1889, p. 144). For many sliding scales of this type, the interval between wage adjustments was as long as six months (Price, 1887a, p. 52). That meant wage adjustments could lag behind the current state of the product market. The scale might call for wage hikes when product prices were clearly falling (Evans, 1909, p. 129), or stable wages - even wage cuts - when prices were rising. “Numerous cases might be cited where strikes have occurred owing to the impatience of the workmen in reference to this matter” (Jeans, 1898, p. 52; see also Smart, 1895, p. 94).

Perhaps more importantly, schemes relying on employers’ books required workers to accept wage cuts based on figures obviously susceptible to the employers’ influence. Apart from outright false accounts, workers suspected that employers gamed the timing of long-term sales contracts to hold down average recorded selling prices (Munro, 1890, p. 126; Chapman, 1903, p. 192); sold to subsidiaries at artificially low prices, “yet can recover profits from the enhanced profits of their subsidiaries” (Political and Economic Planning, 1936, p. 176); and bought inputs at artificially high prices from other firms under the same ownership to reduce the recorded margin between product prices and nonlabor costs (Virtue, 1900, p. 7).

Finally, a worker could not inspect the employers’ books for himself. Because employers did not want to reveal sales information to competitors, they insisted that the accountants or union
representatives examining the books reveal only the average price or margin figure used in the wage formula (e.g. Munro, 1890, p. 170; Jeans, 1898, p. 78; Smart, 1895, p. 66; U.S. Industrial Commission 1901, p. 96). In one British scale, “even the average price is kept secret, and the rate of wages due by the scale is alone made known” (Price, 1887a, p. 59). In many cases, workers suspected that their appointed agents were fooled by employers, or even colluding with them, especially when the reported average price figure differed from published open-market prices (Sydenstricker, 1916, p. 34-35; Great Britain, 1892, volume 1 p. 77; Smart, 1895, p. 95).

Considering these problems, the British Industrial Commission concluded: “The only remedy seems to be..that the workmen at large should implicitly trust their representatives, and delegate the fullest powers to them” (Great Britain, 1894, p. 42). Some unions lacked a sufficient degree of trust. For the American anthracite scale of 1869, prices were secured by an operator and the president of the W.B.A. [the union] going to Philadelphia to get figures from the books of the selected operators. In October, the committee reported that the price of coal was below $3 a ton at Port Carbon. The cry was immediately raised that the committee had been bought by the companies, and some collieries went on strike (Roberts, 1901, p. 178).

8 What was special about mining and metals?

What were the characteristics of mining and metals industries that made them specially suitable for sliding scales? Mining has two obvious advantages, given the problems caused by product diversity and materials costs in other industries: a mine’s output was extraordinarily homogenous, and “the price of the product would not be disturbed to any extent by variations in the price of purchased materials” (Rae, 1892, p. 388) because materials costs were a relatively small fraction of output value. The last point is confirmed by Table 1, which shows materials cost shares calculated from data in the U.S. 1890 census, for manufacturing as a whole, the particular manufacturing industries mentioned above, and the types of mining for which costs and output value were clearly reported.

The metals industries did not share these characteristics of mining. As indicated by the table,
iron and steel materials’ costs were relatively high, if anything. Asked about his industry’s advantages for sliding scales, a leader of the ironworkers’ union told the U.S. Industrial Commission that its products were not especially homogenous:

Q. Would it be much more difficult to fix the wage scale in other industries than in the iron, steel, and tin?...Is not the iron, steel and tin industry more easy to fix a scale in than any other manufacturing industry?

A. I do not know if that be the case or not...If it is a matter of diversity in the product, not; because I believe we have a greater variety of products in the iron, steel and tin mills than any other trade can show (U.S. Industrial Commission, 1901, p. 388)

So why could sliding scales succeed in the metals industries? According to contemporary observers, it was because there were unusually strong correlations between the prices of the industries’ various products, and between prices of products and costs of the industries’ raw materials. Thus, a sliding scale could be based on prices of one or two standard products (Munro, 1885, p. 6; U.S. Industrial Commission, 1901, p. 98; Marshall in Price 1887, p. xx).8

9. Conclusion

Pre-1940s sliding scales were devices to forestall strategic strikes in institutional environments where unions were unable to enter contracts. They emerged and persisted where unions faced profit-maximizing employers with private information about product demand, and workers had sufficient independent information about product prices and materials costs. In mining, sliding scales could work because materials were unimportant and products were homogenous. In the metals industries, sliding scales may have worked despite the importance of materials and specialized products because their prices were unusually well-correlated with standard products’ prices.

8Unfortunately, these statement cannot be checked against data in any meaningful way. Historical wholesale price time series include prices of standard metal products but not specialized products or nonlabor inputs (iron ore and coke). For lists of U.S. prices regularly collected in the late nineteenth and early twentieth centuries, see U.S. Senate Committee on Finance (1893), U.S. BLS (1902).
The results of historical sliding-scale experiments indicate that their administrative costs were negligible, but observable list- and open-market prices could be inadequate signals of product prices and nonlabor costs. On the product side, such prices differed from prices actually received by an employer because of product differentiation, long-term sales contracts, special discounts and surcharges. Materials’ spot prices differed from true materials cost simply because employers could hold stocks. In fact, the availability of published open-market price information was largely irrelevant for the success of sliding scales in an industry. In cotton textiles, sliding scales failed despite a relative abundance of such information. In coalmining and metals, open-market prices were available, but most sliding scales instead relied on prices taken from employers’ accounts.

The apparent shortcomings of list- and open-market prices for sliding scales suggest that the postwar proliferation of wholesale price statistics made little practical difference for wage indexation. Comparing postwar WPIs with actual transactions prices for goods in the same categories, Stigler and Kindahl (1970) found that correlations between the two were “not high...and neither series systematically leads the other” (p. 9), because WPIs were based on list- and open-market spot prices, while most actual transactions were subject to long-term contracts and secret discounts (pp. 6-17). Certainly, long-term sales contracts, discounts and rebates remain common in product markets (Blinder et. al., 1998, p. 92-95; Zbaracki et. al., 2004). A producer’s cost of materials subject to transport and storage costs and uncertainty about future spot prices remains hard to define even in theory, under unrealistically simple assumptions (Husted and Kollintzas, 1987).

Sliding scales based on employers’ account books, on the other hand, were subject to problems that reflected fundamental information asymmetries. Because employers wanted to keep sales information confidential, such schemes could succeed only where rank-and-file union members trusted agents such as union leaders to monitor the accounts. Thus, information asymmetries between workers and their agents, as distinct from asymmetries between employers and the union side per se, were an important constraint on the use of sliding scales. These problems did not
disappear after the 1930s: firms have remained extremely reluctant to reveal sale prices on their books (Stigler and Kindahl, 1970, pp. 23-26), while unions have continued to suffer from members’ unwillingness to trust decisions of better-informed leaders (Ashenfelter and Johnson, 1969).

Given that the information problems associated with product-price indexation were similar before and after the 1940s, the disappearance of sliding scales can be explained as a result of institutional developments that changed the nature of employment bargaining. In Britain, government controls broke the potential links between product prices and wage bargains in the industries where sliding scales had been practical before. In the U.S., the new NLRB system created the option of fixed-wage (or CPI-indexed) contracts, which gained some of the potential benefits of sliding scales by constraining workers’ ability to strike within a contracts’ duration.

In the end, the history of sliding scales shows that workers’ information about product prices and nonlabor costs can be imperfect in ways that are practically important for wage indexation, even under the most favorable circumstances. Sliding scales existed before 1940s precisely because they were not elements of long-term contracts. Thus, their history is actually consistent with arguments that employment bargainers have strong incentive to link wages to product prices, but information problems limited the potential benefits of product-price indexation in postwar union contracts. In a macroeconomic model it may be a reasonable shortcut to simply rule out indexation of wage rates to own-product prices or other enterprise-specific variables, even if the model allows for other types of indexation.

**Appendix: Model details**

Starting from expression (1) in the text, the variable cost of production at a fixed wage $W$ is:

$$C = \Omega + MPY + WL = \Omega + MPY + W^\frac{1}{\frac{\gamma}{\lambda}} K^{-\frac{\delta}{\lambda}}$$

(15)

At the profit-maximizing level of output corresponding to (4) and (5) in the text, a firm’s operating profit before deducting the fixed operating cost is:
The marginal revenue product of capital, taking the product price as given, is:

\[
OP(W, Z, K) = \Lambda \frac{1}{\Lambda^{(\gamma-1) - \Lambda^{\gamma}}} \left[ K^{(\gamma-1)\Theta} Z^\gamma W^{-(\gamma-1)\Lambda} \right] \frac{1}{\Lambda^{(\gamma-1) - \Lambda^{\gamma}}}
\]  

(16)

Assuming strikes occur as described in the text, in period zero firms choose \( K^{STR} \) such that:

\[
R = (1 - \Pi) R(W_H(K_{STR}), Z_H, K_{STR}) + \frac{\Pi}{2} R(W_L(K_{STR}), Z_L, K_{STR})
\]  

(18)

Substituting (17) into (18) and solving for \( K_{STR} \) gives (8) in the text.

In order for the union to follow the strike strategy in the absence of contracts, but offer a long-term fixed-wage contract if possible, it must be true that:

\[
W_L(K_{STR}) < I_{STR}^e < W_L(K_{CON})
\]  

(19)

For strikes to occur absent contracts it must also be true that the firms accept the union’s first offer if and only if demand is high, and accept the second offer if demand is low, which requires:

\[
\frac{\Omega}{OP(W_L, Z_L, K_{STR})} < 1
\]  

(20)

\[
OP(W_H, Z_H, K_{STR}) - \Omega > OP(W_L, Z_H, K_{STR}) - OP(W_H, Z_H, K_{STR})
\]  

(21)

\[
OP(W_H, Z_L, K_{STR}) - \Omega < OP(W_L, Z_L, K_{STR}) - OP(W_H, Z_L, K_{STR})
\]  

(22)

(20) ensures that firms cover their fixed operating cost at the low wage, even if \( Z \) is low; (21) and (22) ensure that the benefit of enduring a strike (the ability to produce at a lower wage in the second period) outweighs the cost (the loss of production at the high wage in the first period) if and only if \( Z \)
is low. (21) and (22) are satisfied as long as:

\[ 2\ OP(W_H, Z_H, K_{STR}) - OP(W_L, Z_H, K_{STR}) > 0 \]  \hspace{1cm} (23) \]

\[ 2\ OP(W_H, Z_L, K_{STR}) - OP(W_L, Z_L, K_{STR}) < \Omega < 2\ OP(W_H, Z_H, K_{STR}) - OP(W_L, Z_H, K_{STR}) \]  \hspace{1cm} (24) \]

The set of conditions on parameters that satisfy (19)-(22) are different depending on whether the union’s wage demands are always within the bounds determined by \( W \) and \( W\Phi \) or are sometimes at one or the other bound, which is to say on the values of \( W \) and \( W\Phi \) relative to the other parameters. Rather than go through all the possibilities, I show that the conditions can hold by examining the case where the relevant wages are always within these bounds. For that case:

\[ W_{HL}(K) = \Lambda K^{(\Gamma - 1)/\Theta} Z_{HL} \]  \hspace{1cm} (25) \]

\[ K_{STR} = \left( \frac{\Theta Z_L}{\Theta} \left[ (1-\Pi) \frac{Z_H}{Z_L} + \frac{\Pi}{2} \right] \right)^{\frac{\Gamma}{\Gamma - (\Gamma - 1)\Theta}} \]  \hspace{1cm} (26) \]

\[ OP(W_L, Z_L, K_{STR}) = \Lambda^{\frac{(\Gamma - 1)\Lambda}{\Gamma - (\Gamma - 1)\Theta}} (\Lambda^{\Gamma - 1} - \Lambda^\Gamma) \left( \frac{\Theta Z_L}{\Theta} \left[ (1-\Pi) \frac{Z_H}{Z_L} + \frac{\Pi}{2} \right] \right)^{\frac{\Gamma}{\Gamma - (\Gamma - 1)\Theta}} Z_L \]  \hspace{1cm} (27) \]

\[ I_{STR}^e = \Lambda K_{STR}^{\frac{(\Gamma - 1)\Lambda}{\Gamma - (\Gamma - 1)\Theta}} \left( (1-\Pi) Z_H + \frac{\Pi}{2} Z_L \right) = \Lambda \left( \frac{\Theta Z_L}{\Theta} \right)^{\frac{(\Gamma - 1)\Lambda}{\Gamma - (\Gamma - 1)\Theta}} \left( (1-\Pi) Z_H + \frac{\Pi}{2} Z_L \right)^{\frac{\Gamma}{\Gamma - (\Gamma - 1)\Theta}} \]  \hspace{1cm} (28) \]

\[ K_{CON} = \left( \frac{\Theta Z_L}{\Theta} \left[ (1-\Pi) \left( \frac{Z_H}{Z_L} \right)^{\frac{(\Gamma - 1)\Lambda}{\Lambda + \Gamma - 1}} + \Pi \right] \right)^{\frac{\Gamma}{\Gamma - (\Gamma - 1)\Theta}} \]  \hspace{1cm} (29) \]

\[ K_S = \left( \frac{\Theta Z_L}{\Theta} \left[ (1-\Pi) \frac{Z_H}{Z_L} + \Pi \right] \right)^{\frac{\Gamma}{\Gamma - (\Gamma - 1)\Theta}} \]  \hspace{1cm} (30) \]
Thus, expression (23) requires:

\[
\frac{Z_H}{Z_L} < 2^{\frac{\Delta K^{-1}}{\Lambda(1 - \Pi)}}
\]  

(31)

which imposes conditions on the relative values of \(\Lambda\), \(\Gamma\), and \(\frac{Z_H}{Z_L}\). Expression (19) requires:

\[
1 < (1 - \Pi) \left( \frac{Z_H}{Z_L} \right) + \frac{\Pi}{2} < \left( (1 - \Pi) \left( \frac{Z_H}{Z_L} \right)^{\frac{\Gamma}{\Lambda(1 - \Pi)}} + \Pi \right)^{\frac{(1 - \Pi)\theta}{\Gamma}}
\]  

(32)

which imposes conditions on \(\Pi\) and \(\Theta\), given (31). Expression (24) requires:

\[
2 \left( \frac{Z_H}{Z_L} \right)^{\frac{\Delta K^{-1}}{\Lambda(1 - \Pi)}} - 1 < \frac{\Omega}{\mathcal{OP}(W_L, Z_L, K_{STR})} < \left( \frac{Z_H}{Z_L} \right)^{\frac{\Gamma}{\Lambda(1 - \Pi)}} \left( 2 \left( \frac{Z_H}{Z_L} \right)^{\frac{\Delta K^{-1}}{\Lambda(1 - \Pi)}} - 1 \right)
\]  

(33)

which imposes conditions on \(\Omega\) and \(\mathcal{R}\), given (31) and (32). Either the right-hand side of (33) or (20) may be binding.

<table>
<thead>
<tr>
<th>Industry</th>
<th>Materials Cost*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manufacturing</td>
<td></td>
</tr>
<tr>
<td>All industries, average</td>
<td>47</td>
</tr>
<tr>
<td>Glass</td>
<td>30</td>
</tr>
<tr>
<td>Cotton textiles (“cotton goods”)</td>
<td>58</td>
</tr>
<tr>
<td>Woolen textiles (“woolen goods”)</td>
<td>62</td>
</tr>
<tr>
<td>Iron and steel</td>
<td>69</td>
</tr>
<tr>
<td>Mining</td>
<td></td>
</tr>
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</tr>
<tr>
<td>Bituminous coal</td>
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<tr>
<td>Copper</td>
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<tr>
<td>Iron ore</td>
<td>15</td>
</tr>
<tr>
<td>Lead and zinc (Kansas only)</td>
<td>13</td>
</tr>
<tr>
<td>Zinc smelting</td>
<td>16</td>
</tr>
</tbody>
</table>
* For manufacturing, includes all materials, mill supplies, fuel and power. For mining, includes all materials, supplies, and purchased fuels.

Source: U.S. Census Office, 1892, pp. 1-422; 1894, Table 2.

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