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Competition, work rules and productivity

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ABSTRACT

I develop a theory to explain why workers want restrictive work rules, those that induce wages to be paid for non-productive labor hours, and why competition reduces them. Work rules allow workers to maintain both high levels of employment and wages. They generate a fixed payment that transfers the firm's surplus to workers, which wages alone cannot do, making them robust to alternative modeling assumptions. Competition loosens work rules by reducing the firm's surplus, which increases productivity.

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1. Introduction

More competitive markets are typically associated with higher productivity (see Aghion and Griffith, 2005; van Reenen, 2011 for surveys of the evidence.) There are a number of cases where an increase in competition led to a jump in productivity. For example, Schmitz (2005) documents enormous increases in labor productivity in U.S. iron ore mining after low cost Brazilian producers entered the market. Similar results have been found in coal mining (Parente and Prescott, 2000), international iron ore mining (Galdon-Sanchez and Schmitz, 2002), Brazilian oil extraction (Bridgman et al., 2011) and U.S. cement (Dunne et al., 2010) (see Holmes and Schmitz, 2010 for a survey of this literature.)

These gains are due largely to improvements at existing firms and are not due to the reallocation of inputs to more productive firms.[1] In each of these cases, there was neither a new nor an old, unadopted technology that was implemented to explain the increase. These studies argue that productivity improved when restrictive work rules, those that induce wages to be paid for non-productive labor hours, were eliminated. For example, Schmitz (2005) finds that the number of job categories declined in U.S. iron ore mines when Brazilian ore entered the U.S. market. When U.S. steel makers faced intense foreign competition in the 1980s, plant managers at U.S. Steel began to violate the work rules in the contract to increase productivity (Hoerr, 1988). Lamarche (2013) finds that reductions in work rules increased productivity in Argentina.

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[1] A complimentary literature has examined the impact of misallocation of inputs on productivity. For example, see Restuccia and Rogerson (2008) and Klenow and Hsieh (2009).

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It is puzzling that workers would want to reduce efficiency when higher productivity would allow employers to pay higher wages. Yet, history is filled with instances of labor unions expending significant organizing resources to obtain and keep work rules. They must serve an important role, which this paper seeks to explain. I develop a theory to explain why workers would want restrictive work rules and why competition reduces them. The model economy features a monopoly firm whose workers care about both total employment and wages. The incumbent workers can dictate wages and work rules. The workers wish to employ all incumbent workers and increase wages. I examine the impact of competition on productivity and why work rules are used instead of all cash contracts.

Restrictive work rules allow workers to push up both employment and wages. Without work rules, increasing employment comes at the cost of reducing wages. Work rules in the form of a fixed labor cost generate a source of labor demand to counteract the wage effect. This additional labor demand allows the union to transfer the firm's monopoly rents to workers. The firm sets set its price as a mark-up over wages, generating a profit margin that wages alone cannot capture. Work rules generate a fixed payment to labor that transfers the mark-up to the workers. In the language of monopoly pricing, the labor contract is a two part tariff with work rules acting as the fixed cost.[2] This mechanism is valuable in a wide variety of settings. As long as there is a mark-up over cost, work rules provide a means for workers to capture it. Therefore, the use of work rules apply beyond the model's specific assumptions.

Competition reduces the restrictiveness of work rules and increases productivity. When new competitors who can sell below the monopoly price enter, monopoly rents fall. Since they are a tool to transfer rents to the workers and there are fewer rents to transfer, work rules are loosened. Maintaining monopoly level work rules would drive the firm out of business.

Despite being an abstract model, it matches a number of features of the data. It predicts that work rules do not change in response to small changes in demand, which is consistent with the evidence. It is also able to match quantitatively the productivity and wage effects of work rules. For reasonable parameter values, it generates these effects for a historical instance of removing work rules.

A major reason for developing the model is to examine methods of increasing productivity when there are work rules. It is difficult to get the firm and union to agree to eliminate work rules on their own. The union will only agree to convert work rules to cash payments if the firm faces no competition. Even when deals are possible, the private gains to firms and workers of such deals are the smallest when the increase in productivity is the largest. Therefore, even small negotiating frictions may prevent deals that would have the biggest impact.

The model suggests that developing policies to increase productivity is surprisingly complex. Exposing a monopoly to imperfect competition will limit work rules, but eliminates the possibility of a deal to eliminate them entirely. Limiting new work rules can be damaging to productivity by inducing resistance to new technology. New, higher productivity technology reduces the power of work rules to increase employment. When demand is sufficiently inelastic, the union will only allow the adoption of new technology if it is allowed to impose more work rules to maintain employment. Therefore, a legal restriction on new work rules could have the unintended consequence of limiting productivity growth.

Other papers have examined work rules. In an appendix, Schmitz (2005) shows that work rules in the form of a fixed cost reduce productivity. This paper extends this insight to an environment where the restrictiveness of these rules are an endogenous outcome. The closest work to this paper is Greenwood and Weiss (2013), who present and parameterize a model of wasteful work rules. While the details of the two models differ, the mechanism is similar: Unions that care about employment levels use work rules to extract surplus. The main difference is in focus. Greenwood and Weiss (2013) focus on quantitatively matching the iron mining example in Schmitz (2005), while this paper focusses on qualitative theoretical results, with particular emphasis on why work rules are so difficult to remove despite being inefficient.

Other papers feature endogenous work rules, but do not generate restrictive work rules. Johnson (1990) finds that if unions care about total employment as well as wages, they may trade off higher wages for employment. These work rules are not inefficient since all labor is used in production. Kahn and Reagan (1993) show that workers with a disutility to labor may use work rules to impose downtime to reduce work effort. These work rules are also not inefficient. Workers trade off higher wages for less strenuous work. I am able to explain restrictive work rules even without disutility to labor. Further, these papers do not examine the impact of competition on work rules.

A related literature has examined the impact of market size on productivity. These papers have generally found that larger market size increases innovation. For example, see Desmet and Parente (2010), Vives (2008) and Bai and Herrendorf (2008). Holmes et al. (2012) predict that a monopolist will adopt new techniques, including fighting to remove work rules, when demand is low. The force they identify, that new technologies are subject to start-up delays, is an additional reason falling demand increases productivity.

This paper is part of a theoretical literature examining productivity and labor unions, including Dowrick and Spencer (1994), Acemoglu et al. (2001) and Lommerud et al. (2006). Alder et al. (2014) examine the role of weak competition, including restrictive union policies, on the U.S. manufacturing. Other papers have investigated the impact of labor unions on the decision to outsource work (Holmes and Snider, 2011) and intermediate goods (Lommerud et al., 2009). A large literature has examined the macroeconomic effects of unions on labor market outcomes, such as Pissarides (1986) and more

[2] The modern two part tariff literature begins with Oi (1971). See Vettas (2011) for a survey.

recently Krusell and Rudanko (2012) among many others, and economic growth, such as Cole and Ohanian (2004) and Ebell and Ritschl (2007). This paper differs from previous work in that it analyzes restrictive work rules.

A complementary theoretical literature, drawing on Olson (1982), that seeks to explain why technological improvements are blocked.[3] New technologies impose costs on incumbent producers and certain frictions prevent those who benefit from higher productivity from compensating those who suffer costs. These frictions can be a lack of commitment to future payments (Kocherlakota, 2001), a change in relative bargaining power (Acemoglu, 2003), informational frictions (Mitchell and Moro, 2006), or inability of "winners" to organize (Bridgman et al., 2007). These frictions will tend to strengthen the impact of work rules by inhibiting compensation deals to remove them.

2. Work rules

Restrictive work rules have been a feature in many industries in the United States and other countries, including a wide variety of mining, manufacturing and transportation industries. A number of these work rules are restrictive: they lead to paid labor hours that do not produce output. This section presents evidence on work rules and explains the choice of functional form used to model them.

2.1. Evidence on work rules

There are work rules requiring jobs that produce no output, sometimes referred to as featherbedding. A classic example is firemen on diesel trains. Firemen had been required on coal fired steam trains to tend the engine. This job was no longer necessary after the conversion to diesel power, but the contract required that engines have a fireman. Another example is the requirement for "witnesses" on bulk loading in Pacific ports. When shipping of bulk goods, such as grain, shifted from loading individual bags to using gravity to pour it into ships, work rules required a gang of longshoremen to watch the loading (Hartman, 1969). The Australian brewing industry employed patmen (workers who cleaned up after horses) in the late 1970s, decades after horses were no longer used (Gilbert, 1987).

Limited substitutability of workers across multiple work categories increases the number of workers that must be employed during a shift. Schmitz (2005) documents that maintenance tasks at Minnesota iron ore mines were separated into a large number of classifications that only could be performed by a worker specialized in that classification. A mine needed to employ at least one worker in each classification, regardless of the amount of ore produced. After the mines faced competition, the number of classifications dropped from nearly 30 to less than 10.

Limited substitutability was common in other industries. In the West Coast longshore industry, there were a number of such rules. Once a gang was called out to a ship, it had to be paid for a full shift even if it did not work the full time and could not be moved to a different ship (Hartman, 1969). Mitchell and Stone (1992) attribute lower productivity in union sawmills in part to limited substitutability across job categories. Hoerr (1988) discusses how the lack of substitutability across jobs in the U.S. steel industry led to so much downtime that reading and sleeping on the job was common. Ichniowski (1984) finds that the number of pages in a labor contract is negatively correlated with productivity.

2.2. Modeling work rules

A key question is how to formally model work rules in way that captures the above examples. I model work rules as a fixed labor cost. Specifically, the union can impose work rules $\kappa \geq 0$ on the production process of the monopoly firm, which uses labor n to produce output

$$y = An - \kappa. \tag{2.1}$$

The firm must hire a certain number of labor hours that are not used in production. This way of modeling captures the work rule examples above. On the margin, the firm is using the technology efficiently but it has to pay for hours that are not used in production.

The choice of this form draws from Schmitz (2005). In an appendix, he proposes two methods to model work rules. Each uses productive and non-productive labor, n_p and n_f respectively. The first, the "fireman" case after the firemen on diesel trains, requires a certain amount of non-productive labor for the plant to operate. (The subscript f refers to firemen.) The above functional form captures this type of work rule exactly. The plant cannot produce unless $n_f \geq \kappa/A$.

A second form is related to limited substitutability. The work rules generate hold-up points that only certain workers can clear. For example, the rules may require a specialist from the shop to turn on a machine. In this case, the firm hires and pays (n_p, n_f) for a shift. The share of that shift where the plant is operating α is an increasing function of n_f. Output of the shift is $y = \alpha A n_p$. This version of work rules is closely related to the first. In both cases, firms must hire non-productive workers to be able to operate.[4] In the fireman case, the choice is binary: either hire enough n_f or produce no output. With limited substitutability, the firm has a menu. If it pays a bigger fixed cost, it is able to operate more hours during a shift. Limited

[3] See Parente and Prescott (1999), Holmes and Schmitz (1995), Krusell and Ríos-Rull (1996) and Herrendorf and Teixeira (2010).

[4] For the functional form $\alpha = 1-(\kappa/An_p)+(n_f/n_p)$ (where α is bounded above by 1), the two cases are equivalent.

substitutability builds in fixed labor payments. If the firm does not pay sufficient fixed cost n_f to avoid downtime, a portion of the productive workers n_p time will become a fixed cost. During downtime, productive workers are paid but do not produce.

I use the "fireman" form of work rules. It has the advantage of simplicity (the model generates closed form solutions) while capturing the payments to non-productive labor that both forms of work rules create.

I abstract from some concerns that may encourage the use of limited substitutability. A significant advantage is that it obscures the degree of featherbedding. With complex production processes, it is not obvious to outsiders how many workers are unneeded. If the featherbedding is too obvious, firms may be able to appeal to a political process to eliminate it. I discuss this and further frictions that help to maintain work rules in the robustness section below.

3. Model

This section presents the model and defines equilibrium. There is one period and a monopoly firm whose workers are represented by a union. The monopoly faces downward sloping demand and the union can impose wages and work rules.

3.1. Model set-up

There is a monopoly firm. Workers are represented by a union, whose membership is all incumbent workers. The size of the union is given by $\overline{n}$.

The monopoly firm uses labor n to produce output $y = An - \kappa$, where $\kappa \geq 0$ are work rules. I exclude capital for expositional clarity. A previous version of the paper included it and generated the same results.

The union sets the wage and work rules. I impose this assumption to focus on why union want restrictive work rules and examine the impact of economic constraints (e.g. competition) on these rules. It abstracts from political factors, such as legal environment for labor bargaining, that influence the degree to which unions are able obtain these work rules. I discuss the impact of such political factors below.

The union's preferences are a version of "insider-outsider" preferences used by Blanchard and Summers (1986) and for which Carruth and Oswald (1987) develop micro-foundations. They are lexicographical in wages and employment. Given a membership of $\overline{n}_1$, the union's preferences are represented by

$$U(n, w; \overline{n}) = n \quad \text{if } n \leq \overline{n} \tag{3.1}$$

$$U(n, w; \overline{n}) = \overline{n} w \quad \text{if } n > \overline{n} \tag{3.2}$$

It wishes to maximize employment if employment is less than $\overline{n}$, the monopoly industry's incumbent workers. Once $n = \overline{n}$, it maximizes wages. When a worker exits the industry, she is no longer a member of the union and receives wage w_0. Members can always leave the monopoly sector, so the monopoly wage must be at least as good than the outside option for the union to retain its membership.

The preferences were selected to match actual union behavior. Beginning with Dunlop (1944), there is a long literature discussing how to model union's preferences (see Kaufman, 2002 for a survey). It emphasizes that unions care about employment independent of wages. Preferences where unions care about employment have been widely used, including in recent work such as Dinlersoz and Greenwood (2012) and Greenwood and Weiss (2013).

These preferences have strong empirical support. Unions sacrifice wages to protect member's employment. Papers documenting this preference include Pencavel (1984) and MaCurdy and Pencavel (1986) for typesetters, Farber (1978) for coal miners and Clark and Oswald (1993) for British unions. Unions also show a preference for higher wages for their members rather than increasing wages. Feiveson (2011) finds that local governments with unionized employees increased wages in response to increased Federal grants while non-unionized governments increased employment. Below, I discuss why unions have these preferences and show that the results are robust to alternative specifications.

Given wage w and work rules κ the union selects, the monopolist sets p to maximize profits. There is a foreign sector that can sell the same good as monopoly sector at price p^F. This sector can supply the whole market at this price. The severity of competition is indexed by p^F: lower p^F means more severe competition. The interpretation is that increasing competition represents falling trade barriers or the entry of low cost producers.

The demand for the monopoly good is given by

$$\begin{aligned} D(p) &= \left[\frac{\theta}{p}\right]^{1/\rho} \text{ if } p \leq p^F \\ &= 0 \text{ if } p > p^F \end{aligned} \tag{3.3}$$

where the parameter θ denotes the size of the market and ρ governs the market's price elasticity. The foreign sector limits the price that the monopoly can charge.

The timing is as follows:

1. Union sets wage/work rule policy.
2. Firm hires labor and sets price.
3. Production/consumption occurs.

3.2. Equilibrium

Given the wage and work rules, the monopolist's problem is to choose p to solve

$$\max_{p,n} \pi = pD(p) - wn$$
$$\text{s.t.} \tag{3.4}$$
$$D(p) = An - \kappa \tag{3.5}$$

The solution to the firm's problem generates profits $\pi(w,\kappa)$ and labor demand $n(w,\kappa)$ that depend on the wage and work rules selected by the union. If the firm cannot make non-negative profits, it does not operate.

The union's problem depends on whether there exists a union policy $\{w,\kappa\}$ that allows full employment $(n(w,\kappa) \geq \overline{n})$ at a wage at least as high as outside option. If so, the union sets the wage as high as is consistent with full union employment and non-negative firm profit. It solves

$$\max_{w,\kappa} w$$
$$\text{s.t.} \tag{3.6}$$
$$\pi(w,\kappa) \geq 0 \tag{3.7}$$
$$n(w,\kappa) \geq \overline{n} \tag{3.8}$$
$$w \geq w_0 \tag{3.9}$$

If not, the union's problem is to maximize employment at the wage of the outside option w_0. It sets work rules at the highest level that is consistent firm operating

$$\max_{w,\kappa} n$$
$$\text{s.t.} \tag{3.10}$$
$$\pi(w,\kappa) \geq 0 \tag{3.11}$$
$$w \geq w_0 \tag{3.12}$$

The definition of equilibrium is standard.

Definition 3.1. An *equilibrium* is monopoly good price p^*, labor allocation n^*, wage w^*, work rules κ^* and output y^* such that

1. Firm solves its problem.
2. The union solves its problem.
3. Markets clear.

4. Results

This section establishes the two main results, showing why unions want work rules and why competition reduces them. I then validate the model by showing that secondary predictions of the model are empirically supported.

4.1. Unconstrained monopoly solution

I begin by assuming that the foreign sector is not competitive ($p^F = \infty$) and demand for the monopoly good is such that full employment can be achieved at a wage above the outside option. This equilibrium is called an *unconstrained monopoly equilibrium*. The associated quantities are labeled with the superscript M.

The model is solved by working backward through the period. Given union policy (w,κ), the monopolist chooses labor and price to maximize profits. The associated price is

$$p(w) = \frac{w}{A(1-\rho)} \tag{4.1}$$

The labor demand is given by

$$n(w,\kappa)=A^{(1-\rho)/\rho}\left(\frac{\theta(1-\rho)}{w}\right)^{1/\rho}+\frac{\kappa}{A} \tag{4.2}$$

Given these reaction functions, the union selects wage and work rules to maximize the wage subject to full employment and not driving the monopoly firm out of business. The union will choose κ and w so that both constraints bind. The unconstrained monopoly wages w^M are given by

$$w^M=\frac{[A(1-\rho)]^{1-\rho}\theta}{\overline{n}^{\rho}}. \tag{4.3}$$

The corresponding work rules κ^M are given by

$$\kappa^M=\rho A\overline{n} \tag{4.4}$$

4.2. Rationale for restrictive work rules

The theory provides an explanation for why workers would want wasteful work rules. They provide an instrument to keep wages high without reducing employment. Without work rules, increasing wages comes at the cost of employment. The union can counteract this effect by adding wasteful work rules. Higher κ increases labor demand by requiring more idle labor be hired.

In what follows, I compare the outcome of the model with a modified model where the union faces the additional constraint that it cannot use work rules ($\kappa=0$). Unconstrained monopoly wages (w^M) are higher than the wage with no work rules (w^{NWR}). This result is formalized in the following proposition.

Proposition 4.1. *If the monopoly firm is unconstrained by competition* ($p^M\le p^F$), *wages with work rules* w^M *are higher than wages without work rules* w^{NWR} *and employment is the same*: $n^M=n^{NWR}=\overline{n}$.

Proof. If the union did not have access to work rules as an instrument ($\kappa=0$), the union chooses the wage such that $n^{NWR}=\overline{n}$. Putting these conditions into Eq. (4.2), this wage is given by

$$w^{NWR}=A^{1-\rho}\left(\frac{1}{\overline{n}}\right)^{\rho}\theta(1-\rho) \tag{4.5}$$

Comparing the wage with work rules (Eq. (4.3)) and Eq. (4.5), wages with work rules are higher ($w^M>w^{NWR}$) if $(1-\rho)^{1-\rho}>1-\rho$. Simplifying, this condition becomes $(1-\rho)^{\rho}<1$. Since $\rho\in(0,1)$, the expression is true. □

The cost of labor is a two part tariff, with work rules acting as the fixed cost. Given a union policy (w,κ), the firm's profits are

$$\pi=\rho(1-\rho)^{(1-\rho)/\rho}\left(\frac{A}{w}\right)^{(1-\rho)/\rho}\theta^{1/\rho}-\frac{\kappa w}{A} \tag{4.6}$$

If there are no work rules ($\kappa=0$), profit is always positive since $\rho(1-\rho)^{(1-\rho)/\rho}>0$. The firm sets its price as a mark-up over marginal cost. The union needs the fixed cost work rules provide to capture this mark-up.

Union prefers this method of imposing work rules to other interventions. The union would not want to force the use of inferior technology. Using a fixed cost pulls a portion of the work force out of production, but does not affect the firm's marginal pricing decisions. (κ does not appear in the pricing equation, Eq. (4.1).) Forcing the use of an inferior technology (reducing A) raises the price, which in turn reduces households' demand for the monopoly good and the labor that produces it. Therefore, the union is not Luddite. Workers use the best technology available when they produce output, they just do not work all the hours they are paid.

The union would not want to force the firm to use all its members in production. This method puts the union back at the wage-employment trade off. The only way to get all workers employed is to accept lower wages relative to the work rule case.

The result does not rely on a disutility of work. The union selects work rules that reduce work effort even though the workers do not mind working harder. Extending the model to include leisure in worker's utility would have two effects. On one hand, valuing leisure strengthens the results since work rules would have the additional benefit of increasing on-the-job leisure. (Greenwood and Weiss, 2013 show that the union will want to impose work rules if wages and rest are complements.) On the other hand, if on-the-job leisure is inferior to leisure enjoyed elsewhere, forcing workers to come in to work (or to stay at work for longer than needed) reduces worker welfare. Below, I discuss in detail the frictions preventing the use of cash payments instead of work rules.

In the model, there is a single monopoly firm. In a multi-firm setting, work rules can help sustain cooperative cartel behavior by equalizing costs across firms. Maintaining a cartel is easier when members face similar costs (Vasconcelos, 2005). In a number of cases, unions have explicitly pursued common wages and work rules across firms. For example, the

United Steel Workers negotiated wages to be exactly the same in the eight largest firms in the U.S. basic steel industry, including the dominant firm U.S. Steel. Most smaller firms would use that same scale (Hoerr, 1988). Such unified contracts across firms were also found with port labor and coal mining.

4.3. Competition and work rules

Now consider the case where competition is binding, called a *competition equilibrium*. This type of equilibrium obtains when the outside price is below the monopoly price for given parameters: $p^F < p^M$. Recall that competition is indexed by the foreign price p^F, with the severity of competition increasing as p^F falls. The model predicts that work rules are less restrictive and productivity increases if competition is more binding.

Competition equilibrium quantities are indexed by the foreign price. Let $\kappa(p^F)$ be the equilibrium work rules associated with price p^F. The following proposition shows that constrained firm has less restrictive work rules compared to the unconstrained monopoly.

Proposition 4.2. *Work rules under competition are lower than under the unconstrained monopoly:* $\kappa^M > \kappa(p^F)$ *for* $p^F < p^M$.

Proof. Work rules under competition are given by $\kappa(p^F) = \max\{A\overline{n} - (\theta/p^F)^{1/\rho}, 0\}$. Combining Eqs. (4.1) and (4.3), the unconstrained price is given by $\theta/[(1-\rho)A\overline{n}]^\rho$. If $p^F < p^M$, then $\kappa(p^F) < A\overline{n} - (1-\rho)A\overline{n} = \rho A\overline{n}$. Since $\rho A\overline{n} = \kappa^M$ (Eq. (4.4)), the result obtains. □

Competition reduces the firm's profit. If the union's policy under unconstrained monopoly were used, the firm would earn negative profits and exit. Therefore, either work rules or wages must be lower. It is work rules that decline. Competition lowers the price the firm can charge, which increases demand for the firm's output and the labor that produces it. Therefore, the union can still employ all its members with fewer work rules (lower κ).

When competition is strong enough, all work rules are eliminated: labor demand increases to the point that all workers are employed without using work rules. Once the foreign price p^F falls below this price, the union can only return the firm to non-negative profits by reducing wages. This price, p^C or crisis price, is defined by the price that sets demand for productive labor equal to union membership: $p^C = \theta/(A\overline{n})^\rho$.

The decline in work rules κ leads to increased productivity. Productivity is given by

$$\frac{y}{n} = A - \frac{\kappa}{n} \tag{4.7}$$

Since work rules are less restrictive, productivity is higher under competition compared to the unconstrained monopoly. For p^F such that $p^M > p^F > p^C$, productivity is given by

$$\frac{A\overline{n} - \kappa(p^F)}{\overline{n}} = \frac{1}{\overline{n}}\left(\frac{\theta}{p^F}\right)^{1/\rho} \tag{4.8}$$

Since work rules are lower while employment is constant, fewer work hours are wasted. The firm is able to meet the increased demand for its product by placing more workers in production.

The impact of competition on work rules and productivity is monotonic: stronger competition, as measured by lower p^F, leads to lower κ. Eq. (4.8) implies that if $p^M > p^F > p^{F,'} > p^C$, then $\kappa(p^{F,'}) < \kappa(p^F)$. The same logic as found in Proposition 4.2 holds. More competition lowers monopoly rents while increasing labor demand. Once price falls below p^C, there are no more work rules to eliminate and productivity does not increase with more intense competition.

4.4. Market size and work rules

The model has predictions aside from the central result linking competition and work rules. These predictions provide tests for the validity of the model. I examine the impact of market size on work rules and how they affect labor's attitude toward new technology. I then examine how well a parameterized model captures the quantitative impact of competition.

I begin by examining the impact of market size (θ) on work rules. Work rules are unaffected by small differences in market size, an observation that is consistent with evidence on union's response to downturns. If the market is small enough work rules decline, but do not imply higher productivity.

The impact of θ depends on whether it is large enough for the union to command a wage premium and employ all its members or not. If $\theta \le \theta^{DC} = w_0\overline{n}^\rho/[A(1-\rho)]^{1-\rho}$, the threshold for a *demand crisis* (DC), the union cannot maintain both goals.

Consider the case where both goals are possible: $\theta > \theta' > \theta^{DC}$. In this case, wages decline with market size ($w(\theta) > w(\theta')$) but work rules are unaffected ($\kappa(\theta) = \kappa(\theta')$). The union's emphasis on protecting the employment of its members means that it will choose lower wages to maintain employment when market size is smaller. Wages chosen by the union (Eq. (4.3)) are a linear function of θ. On the other hand, the union's work rule decision is not dependent on market conditions (Eq. (4.4)).

Now suppose θ falls below the demand crisis threshold: $\theta > \theta^{DC} > \theta'$. There are insufficient rents to maintain work rules for θ'. In this case, the union chooses smaller work rules to maintain as much employment as possible at the outside wage.

Though work rules are lower, productivity does not change. The fixed cost generates increasing returns to scale. Producing at a smaller scale for a given fixed cost reduces productivity. While there is less wasted labor input, which increases productivity, employment is falling. The two forces exactly counter each other, leaving productivity unchanged.

An interpretation of these comparative statics is that they show what happens to work rules in response to changing demand: Each period is a play of the static game. Therefore, they show what the model predicts for work rules over the business cycle where a lower θ represents recessions.

The finding that unions give reduce wages before work rules as market size falls is consistent with findings of the concession bargaining literature. Freeman and Kleiner (1999) find that unions drive up wages but not to the point that maintaining production (thus employment) is threatened. Henle (1973) documents a number of cases unions accepted wage cuts during poor economic times in exchange for employment guarantees. Greenberg (1968) finds that union locals are willing to accept lower wages to preserve employment. Bastos and Wright (2012) find that unions adjust wages down in response to currency appreciations.[5]

The lack of concessions on work rules is also empirically supported. Facing a serious decline in demand in the early 1980s, workers at the large steel companies cut wages but did not give any concessions on work rules. It was only when demand had fallen severely that concessions were made on work rules (Strohmeyer, 1994).

4.5. Work rules and new technology

Up to this point, the underlying technology has been fixed. Work rules can also constrain productivity by inducing resistance to new technology. More productive technologies (increasing A) weaken the ability of work rules to increase employment. When the union cannot tighten work rules in response, it may block the new technology. Paradoxically, the firm's ability to increase productivity through technology adoption may depend on the union's ability to reduce productivity through work rules.

In what follows, I examine whether the union would agree to adopt a new, more productive technology given the wages and work rules implied by the old technology: when would the union would allow the productivity factor to increase from A to A' holding wages and work rules at their initial levels $w(A)$ and $\kappa(A)$? In cases where the union would not allow adoption, I then show how work rules have to change to get the union to support the new technology.

In the unconstrained monopoly case, increasing A has two competing effects on labor demand. On one hand, it increases demand for productive labor by lowering marginal costs and consumer prices (the first term in Eq. (4.2)). On the other, it weakens the impact of work rules (the second term). New technology will cut employment when the work rule force dominates. Since maintaining employment is the union's first priority, it would oppose increasing A.

The work rule effect will dominate if demand is sufficiently inelastic. In this case, the firm produces little output and demands little labor. New technology does not increase the demand for productive labor much and work rules are very restrictive (κ is high). Since most labor demand is non-productive labor, weakening work rules has the stronger effect on overall labor demand. Holding wage and work rules constant, the following proposition establishes conditions under which new technology reduces labor demand.

Proposition 4.3. *Let w^M and κ^M be the unconstrained monopoly wage and work rules associated with productivity A. For $A' = \gamma A$, where $\gamma > 1$, $n(w^M, \kappa^M, A') < n(w^M, \kappa^M, A)$ if $(\gamma^{1/\rho} - \gamma)/(\gamma^{1/\rho} - 1) < \rho$.*

Proof. Using the labor demand (Eq. (4.2)), and putting in unconstrained monopoly wage w^M and work rules κ^M generates the condition. □

In the constrained firm case, the price effect is no longer present since the outside competition sets prices. Labor demand is given by

$$n(w, \kappa, A) = \frac{1}{A}\left(\frac{\theta}{p^F}\right)^{1/\rho} + \frac{\kappa}{A} \tag{4.9}$$

Work rules are weakened, as before, but new technology no longer increases demand for productive labor. Increasing A just means fewer productive workers are required to produce that output.

If the union can adjust work rules, it is always willing to adopt the new technology. It adjusts the work rules (increases κ) to compensate for the fall in labor demand and all members are employed. This tightening of the work rules explains why many work rules take the form of retaining redundant crew members. Empirical examples of this tightening include the firemen requirement for diesel trains and witnesses in Pacific ports. In these cases, a work rule was added that kept labor demand at its original level.

Differences in the union's ability to set work rules can explain why it will support new technology in one instance while opposing it in another. For example, the West Coast longshoremen's union required that goods on pallets be removed and re-palleted in the port while it allowed bulk loading. The main difference between the two was how much control the union had over production. It was able to require witnesses for bulk loading, so it did not oppose that technique. On the other

[5] These findings also give support to the assumption that unions care about employment, even at the cost of wages.

Table 1
Model simulations.

Variable	Cement: Southwest U.S.	U.S.	y/n target	Robust: y/n doubles
Elasticity $-1/\rho$	−2.96	−5.70	−4.57	−2
Productivity gain $\frac{y^{NWR}}{\overline{n}}/\frac{y^M}{\overline{n}}$	1.51	1.21	1.28	2.00
Wage premium w^M/w^{NWR}	1.15	1.04	1.06	1.41

hand, it faced a jurisdictional battle with the Teamsters over which union's workers were allowed to place goods on pallets. As a compromise, both unions' workers did the job. In Portland, an arbitrator ruled that the goods were not to be removed from the pallet. The employer just paid for the extra hours it would have take to do so (Hartman, 1969). Even the original Luddite uprising in England was more about jurisdictional issues (who was allowed to use new machinery and how it was used) than a protest against new technology itself. Damaging equipment was a tactic to get recognition of workers' demands (Conniff, 2011).

4.6. Quantitative results

While the model is abstract, it does remarkably well in quantitatively capturing movements in productivity and wages. I apply the model to a historical instance where competition removed work rules. Dunne et al. (2010) show that productivity in the U.S. cement industry increased while wages fell after an increase in foreign competition in the cement industry in the 1980s. I compare wages and productivity with and without work rules using values of the parameters from the empirical literature. The model is consistent with observed changes in productivity and wages. It does not need unrealistic parameter values to generate significant productivity effects, nor does it generate counterfactual wage premia.

In the model, the ratio of productivity without work rules (NWR) to the unconstrained monopoly (M) is given by

$$\frac{\frac{y^{NWR}}{\overline{n}}}{\frac{y^{M}}{\overline{n}}} = \frac{\frac{A\overline{n}}{\overline{n}}}{\frac{A\overline{n}-\kappa}{\overline{n}}} = \frac{A}{A-\frac{\kappa}{\overline{n}}} \tag{4.10}$$

Putting in the solution to κ from the unconstrained monopoly case, this expression becomes $1/(1-\rho)$.

The wage premium that work rules generate is given by

$$\frac{w^M}{w^{NWR}} = \frac{1}{(1-\rho)^{\rho}} \tag{4.11}$$

The impact of work rules on productivity and wages are both determined by the elasticity of demand $-1/\rho$. The literature provides estimates of this elasticity for cement. Miller and Osborne (2011) estimate a median demand elasticity of −5.7 for the cement firms in the U.S. Southwest. In his baseline specification, Ryan (2012) estimates the U.S. elasticity of demand to be −2.96. The first two columns of Table 1 report the model's predictions for the ratios of productivity and wages with and without work rules for these elasticities. The “Productivity Gain” row shows how much productivity increases if work rules are removed (Eq. (4.10)) and the “Wage Premium” row reports how much work rules drive up wages (Eq. (4.11)). The model predicts a productivity increase of 21–51% and a wage premium of 4–15%, depending on which elasticity is used. Observed changes in the cement industry in the 1980s fall in this range. Dunne et al. (2010) calculate that within plant productivity rose 28% between 1982 and 1987. At the same time, the hourly wage for cement production workers relative to all manufacturing wages were 7.3% higher prior to competition.[6] In the third column, I set the elasticity to −4.57, which exactly generates the empirical increase in productivity. The model's wage premium is 6%, which is very close to the observed premium of 7%.

Work rules are more restrictive with more inelastic demand, which implies a larger wage premium and a larger impact of work rules on productivity. Work rules halve productivity in the most restrictive examples in the data. (Labor productivity in U.S. iron ore mining nearly doubles after competition (Schmitz, 2005). Greenwood and Weiss (2013) calibrate their model to this case.) The fourth column reports a robustness exercise, where the elasticity is chosen to generate a doubling of productivity when work rules are removed. Work rules generate a 41% wage premium, which falls within the empirical range. The average union wage premium in the data ranges from 10 to 20%, with some industries showing a 50 wage premium (Blanchflower and Bryson, 2011).

[6] Productivity change is taken from Dunne et al. (2010), Table 1. Wages are SIC 3241 average production worker wages from the Census of Manufactures divided by average manufacturing wage, *2010 Economic Report of the President* Table B.47.

5. Robustness

This section examines the robustness of work rules. I show that it is difficult to get the union to agree to use stop using work rules. Allowing for alternative payment schedules or changing union preferences are not enough to eliminate work rules in many cases.

5.1. *Cash instead of work rules?*

A key question is why are not excess workers sent home instead of kept at work? Could the union and the firm agree to an all-cash payment schedule instead of work rules? The model predicts that it may be possible when the monopoly is unconstrained, but impossible under competition. The rare empirical instances of compensation deals lend support to this finding. The model also predicts that the private gains to buy-outs are the smallest when they have the biggest impact on productivity. Even small negotiating frictions may prevent the most economically significant deals from being made.

5.1.1. *Unconstrained monopoly compensation*

I begin by considering whether an unconstrained monopoly firm and union can come to an agreement on removing work rules. From the above analysis, we know that such agreements must retain the two part tariff structure. Therefore, I examine buy-outs where each union member receives a lump-sum transfer T and a wage w^B in exchange for setting $\kappa = 0$.

For the union to agree to the scheme, each member must receive at least the same total payments (transfers plus wages) as wages under work rules ($T + w^B \geq w^M$) and all union members must be employed ($n(w^B) \geq \overline{n}$). In addition, the new wage must be higher than the outside option wage to keep members from leaving the union: $w^B \geq w_0$. For the firm to offer compensation, buy-out profits π^B must be at least as high as those under the work rules π^M.

The deal that makes the union indifferent between work rules and compensation is $T = w^M - w^B$ and $w^B = w^{NWR}$. Workers get the same income (a lower wage plus a transfer) and they are all employed.

Given this compensation scheme, the firm will always want to buy out work rules. Profit under the buy-out is

$$\begin{aligned}\pi^B &= p(w^{NWR})y(w^{NWR}) - w^{NWR}\overline{n} - (w^M - w^B)\overline{n} \\ &= p(w^{NWR})y(w^{NWR}) - w^M\overline{n}\end{aligned}$$

The labor payments are unchanged in the buy-out. Therefore, $\pi^B \geq \pi^M$ if $p(w^{NWR})y(w^{NWR}) \geq p(w^M)y(w^M)$. Sales are strictly decreasing in w. Since $w^{NWR} < w^M$, the firm's profit is higher under the buy-out.

The union will not always accept the buy-out. Recall that the union will accept the buy-out offer if $T + w^B \geq w^M$, $n(w^B) \geq \overline{n}$ and $w^B \geq w_0$. The buy-out was set to satisfy the first two constraints. If $w^{NWR} < w_0$, it is impossible to have both a wage premium and full employment without work rules. The union's desire to maintain employment in the industry prevents a deal from being struck.

When will a buy-out not be possible? The no-compensation case $w^{NWR} < w_0$ applies if $\overline{n}$ is large, since there are too many workers to employ given the level of market power. This condition also applies if the firm has a high degree of market power due to very inelastic demand (ρ large). The firm produces little output at a very high price. Hence, there is low demand for (productive) workers and large margins on production. Removing work rules reduces employment significantly, so wages must fall sharply to counteract the loss of labor demand.

While compensation deals are generally possible, they do not yield significant gains in firm profit when they have the biggest impact on productivity. Recall that firm prefers the deal since it increases sales while holding costs constant. When demand is very inelastic (ρ is close to one), sales (and profits) do not increase much. It is precisely when work rules are the most restrictive that buying them out has little impact on profit. Therefore, relatively small contracting frictions may enough to prevent a deal from being made.

5.1.2. *Competitive compensation*

Compensation is not possible if the firm is constrained. The firm will still want to offer a buy-out deal but the union will not accept it since it reduces employment.

Consider the compensation deal $w^B = w_0$ and $T = (w(p^F) - w_0)\overline{n}$. The firm's profits under the deal are

$$\pi^B = \theta^{1/\rho}\left(\frac{1}{p^F}\right)^{(1-\rho)/\rho} - w(p^F)\overline{n} + w_0(\overline{n} - n) \tag{5.1}$$

The firm's profit increases by shedding excess workers. (The final term in Eq. (5.1) is the increase in profit from sending workers to other industries.) Since workers must leave the industry, the union will not accept it. In fact, the firm's willingness to offer the deal depends on employment falling. Since the firm is a price taker, reducing wages does not increase labor demand. Under competition, labor demand is

$$n = \left(\frac{\theta}{p^F}\right)^{1/\rho}\frac{1}{A} + \frac{\kappa}{A} \tag{5.2}$$

The only instrument the union has to increase employment is to increase non-productive labor through work rules. Since work rules are the only thing keeping all union members employed, the monopoly cannot offer a buy-out that maintains full employment.

This finding suggests a tension in introducing competition. Exposing a monopoly to imperfect competition – that which limits but does not remove work rules – may have unintended consequences. Competition limits work rules but eliminates the possibility of a deal to eliminate them entirely. This case and the technology adoption case considered above suggest that partial measures that limit but do not eliminate work rules can be counterproductive. The monopoly may have the highest productivity when it is the freest to reduce productivity through work rules.

5.1.3. Evidence on compensation

While compensation deals are not common, there have been historical instances where they have occurred. The theory predicts that such deals are possible when there is little competition. Two prominent examples are consistent with this prediction.

In 1960, the longshoremen's union on the U.S. West Coast agreed to eliminate restrictive work rules, both formal and informal, in exchange for various payments and fringe benefits. Registered workers who met minimum work requirements were guaranteed a 35 hour week's wages (Hartman, 1969). When the deal was agreed to, there was very little competitive pressure. All ports on the West Coast are unionized by a single union and are subject to a single contract. Essentially all Pacific trade had to go through these ports. Long range jets had not been developed and alternative entry points were costly and far from West Coast markets.

In 1950, the United Mine Workers (UMW) agreed to eliminate rules on the use of machinery in bituminous coal mines in exchange for payments to a welfare fund that paid for pensions, disability payments and health care. Due to the cost of shipping, foreign producers were not competitive in the U.S. market. The industry nearly entirely organized by the UMW, with its mines accounting for 90% of U.S. coal production in 1948 (Navarro, 1983).

5.1.4. Contracting frictions

The model predicts that the firm and union could agree to a buy out of work rules under some circumstances. However, there are frictions outside that model that make it difficult to come to such an agreement. Some of these frictions are under the control of policy and may explain differences in the use of work rules.

Unions and employers are legally limited in what contracts they can negotiate. In particular, U.S. labor laws restrict labor contracts with fixed payments. Under the Fair Labor Standards Act (FLSA), payments must be tied to hours worked and can only be used to smooth out irregular work opportunities. This provision was intended to keep employers from circumventing overtime laws. While these laws do not forbid fixed payments entirely, they do restrict what deals employers and unions can make. In the years after the FLSA was passed, the Department of Labor was aggressive in bringing suits against firms that used fixed labor payments. The volume of litigation and contradictory rulings led to uncertainty as to what contracts were legal (Walling, 1948). This period of uncertainty coincided with a period of major expansion of unionization (Dinlersoz and Greenwood, 2012). In contrast, Japanese labor compensation features large fixed payments (Freeman and Weitzman, 1987). The model suggests that it is not a coincidence that unionized Japanese firms have much more flexible work rules (Lincoln and Boothe, 1993).

Even if a legal contract could be negotiated, it can be difficult for the firm to commit to paying workers who are not working or working other jobs. The JOBS program, which paid auto workers most of their wages even if they did not work, was eliminated by Congress when GM was taken over by the U.S. government due to its political unpopularity (Michaels, 2009). Unions may be suspicious that the firms will use public pressure or bankruptcy to get out of their obligations in the future, especially since unemployment payments are typically high when the firm's sales are low. One commitment device, having the union control a fund that paid the benefits, was restricted in the United States. The passage of Taft–Hartley created uncertainty about which such funds were legal (Kennedy, 1962). Work rules are harder for employers to eliminate unilaterally. Workers usually have significant control of the production process and can effectively resist management's efforts to cut work rules by slowing or stopping production (Hammett et al., 1957). Efforts by West Coast shippers to get rid of work rules that the union had agreed to eliminate in the Port of Los Angeles/Long Beach failed for decades (Finlay, 1988). Such political constraints may explain why most pure featherbedding jobs, such as the firemen and patmen, are leftovers from previous production processes. Protecting workers whose jobs were eliminated is more politically palatable than creating new make-work jobs.

Unions may also worry that giving up work rules will weaken its ability to organize. It is easier to coordinate workers when they are all in the same place, rather than have a group at home or working other jobs. It also aligns the incentives of workers. If excess workers are paid off but retain union membership, two classes of union members are created: workers and nonworkers. Nonworkers will want high unemployment benefits and have little interest in high wages and other workplace issues while current workers will weight the latter goals more highly. This conflict occurred within the UMW since most members did not work as miners (Farber, 1978).

5.2. Union preferences

A key friction that generates the use of work rules is that the union cares about employment. This section discusses why unions care about employment and shows that the results are robust to alternative specifications of preferences.

5.2.1. Why care about employment?

Union's preferences for employment independent of wages is a robust empirical finding. There are a number of reasons for the union to pursue employment as a goal.

Protecting employment provides insurance to its members.[7] There is a trade off between high wages and employment. If the union only cared about wages, it would want to reduce employment. Individual workers would be vulnerable to being laid off and receiving no wage premium. Choosing to favor employment over wages provides a form of unemployment insurance. Risk averse members are willing to accept lower wages to reduce their chance of losing the wage premium of a union job. Empirically, union members tend to have high degrees of risk aversion. Goerke and Pannenberg (2008) find that German union members are more risk averse than non-members. The UMW also exhibited high risk aversion (Farber, 1978).

Members may wish to commit their union to prefer full employment beyond what a simple static vote would yield. Union voting is vulnerable to coalitions. Due to the trade-off between employment and wages, coalitions within the union have an incentive to have other members laid off to increase their wages. This tension could lead to the union dismantling itself.[8] To see why, suppose union policy is set by majority vote of members and layoffs are done by seniority. If union policy is set to satisfy the worker with median seniority, there is an incentive for senior workers to vote for higher wages for themselves at the expense of junior workers' employment. As this process is iterated, the union will vote itself out of existence. Each contract vote will cause the junior half of the union to be laid off, until there is only the most senior worker is left. Designing the union's constitution so that it is committed to accepting lower wages for full employment protects junior workers and prevents it from self-destructing. Further, Kidd and Oswald (1987) suggest that forward looking union members will vote to protect employment to prevent this dismantling process from beginning.

5.2.2. Work rules are robust

While union's preference for employment is firmly supported by the evidence, the use of work rules is much more general. The firm sets its price as mark-up over marginal cost independent of the union's preferences. Therefore, the motive to use of work rules as part of a two part tariff to extract monopoly rents is not specific to the union utility function used above.

The union will use work rules even if it does not care specifically about employment or its members over outsiders. Holding the firm's problem constant, suppose the union only cared about the total wage bill

$$U(n, w) = n * w \tag{5.3}$$

The union only wishes to maximize total labor payments and does not care how many of its members are employed.[9] The solution to the union's problem is $w = w_0$ and $\kappa = \rho(1-\rho)^{(1-\rho)/\rho}[A\theta/w_0]^{1/\rho}$.

The union wishes to maximize sales since higher sales mean more use of labor. Sales are higher when wages are low, so the union sets wages at the lowest wage that will retain workers (the outside option w_0). Work rules serve the same purpose as before. They increase labor demand for a given wage, further increasing the wage bill.

Work rules are a useful as long as the union cares about employment at all, not just for the insider-outsider preferences used in the model. In a model where unions care about both wages and employment, McDonald and Solow (1981) show that the outcome of bargaining when the union can only negotiate wages will be Pareto inferior to the outcome when both wages and employment can be negotiated. The union would be better off if employment was higher than what the labor demand function implied, while the firm would make the same profits. Work rules provide an instrument to negotiate on employment directly. In fact, McDonald and Solow (1981) note in passing that featherbedding (work rules) could be Pareto improving due to this effect, but do not pursue the issue.

6. Conclusion

This paper contributes toward developing a theory of productivity. It gives an explanation for why a technology may be operated inefficiently in non-competitive industries. Adding non-productive paid work hours allows workers to maintain employment while keeping wages high.

The model suggests that designing policy to increase productivity when work rules are present is surprisingly complex. The obvious answer – increase competition – may be counterproductive. A small increase in competition will reduce work rules, but makes a deal to eliminate them entirely impossible. Restricting workers' ability to impose work rules has the

[7] The literature on labor unions has often emphasized their role in providing income insurance. For example, see Agell and Lommerud (1992) and Horn and Svensson (1995).

[8] See Burda (1990) for a fuller survey of this issue.

[9] These are the preferences proposed by Dunlop (1944) and used more recently by Krusell and Rudanko (2012).

benefit of running the current technology more efficiently, but may prevent adoption of new technology. Rules adopted for other purposes, such as restricting fixed labor payments, may have the unintended consequence of encouraging work rules.

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