Competition and Productivity

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Abstract

More competitive markets are associated with higher productivity. However, changes in competition complicate productivity measurement since changing mark-ups may shift factor shares. This paper examines productivity measurement in markets with market power and restrictive work rules: rules that induce wages to be paid for non-productive labor hours. It develops a theoretical model to explain why workers would want restrictive work rules and how competition leads to their reduction. I model a monopoly firm whose workers dictate wages and work rules. Work rules allow workers to maintain both high levels of employment and wages. Competition reduce work rules and increase productivity by lowering mark-ups. The theoretical findings are consistent with the empirical literature on the impact of increasing competitive pressure on productivity.

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1 Introduction

More competitive markets are typically associated with higher productivity. (See Aghion & Griffith (2005) for a survey 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 & Prescott 2000), international iron ore mining (Galdon-Sanchez & Schmitz 2002) and cement (Dunne, Klimek & Schmitz 2009). (See Holmes & Schmitz (2010) for a survey.) These gains are due largely to improvements at existing firms and are not due to the reallocation of inputs to more productive firms. In each of these cases, there was neither a new nor 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. 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 the market for U.S. steel makers collapsed in the 1980s as foreign producers entered the market, plant managers at U.S. Steel began to violate the work rules in the contract to increase productivity (Hoerr 1988).

Why does competition reduce restrictive work practices and increase productivity? Economic theory typically predicts that productivity should increase when a firm's market is expanding since the benefits of reducing costs are higher when spread across a larger market. For example, see Desmet & Parente (2010), Vives (2008) and Bai & Herrendorf (2008). Therefore, it is puzzling that productivity should jump when a firm's market is being squeezed by new competitors.

An exception is Holmes, Levine & Schmitz (2008), which predicts that a monopolist will adopt new technology when demand is low due to start-up delays. They explicitly discuss work rules and suggest that firm owners will fight to remove work rules when demand is low since doing so risks a shutdown due to strong opposition from labor. Conflict over this issue has led to significant labor strife, including lengthy strikes and lockouts. Restrictive work rules must accomplish a goal that is valuable to workers for them to fight to protect them even in dire circumstances.

A typical rationale for these rules is to maintain employment. Indeed, Eberts & Stone (1991) find that unionized firms increase the use of labor relative to other inputs. However in standard models, more efficient firms pay higher wages and employ more workers. If workers care about total employment as well as wages, as in Johnson (1990), a union may trade off higher wages for employment[1]. This theory does not generate genuinely restrictive work rules since workers do not want labor resources wasted. Another explanation is that there is a disutility to working, and work rules impose downtime giving the worker more leisure (Kahn & Reagan 1993). This explanation begs the question why workers do not work all the hours they are on the clock in exchange for higher wages and enjoy their leisure away from the workplace, where leisure is presumably more enjoyable. It also does not explain why workers are only willing work more strenuously when the industry is under distress.

This paper develops a theory to explain why workers would want restrictive work rules and why competition reduces them. I also examine how work rules can induce resistance to new technology. I study a model economy with a monopoly industry whose workers care about both total employment and wages. The incumbent workers, those that worked in the industry in the previous period, can dictate wages and technology. The workers wish to employ all incumbent workers and drive up wages. There are demand shocks for the monopoly industry's product. I examine the outcomes of the model with and without competition.

I argue that if workers care about both employment and wages, that they will want restrictive work rules that take the form of a fixed cost. Without work rules, increasing employment comes at the cost of reducing wages. Restrictive work rules in the form of a fixed labor cost generate a source of labor demand to counteract the wage effect. If the additional hours were used in production, the firm would have to reduce prices to generate demand for the extra production. The workers prefer to waste some work hours to limit production and keep monopoly profits high.

Competition leads to the reduction of restrictive work rules. When new competitors who can sell below the monopoly price enter, mark-ups are reduced. Maintaining the

[1] MaCurdy & Pencavel (1986) find evidence that the typesetters union sought to maintain employment, not just increase wages.

monopoly level work rules and wages would reduce profitability to the point of driving the firm out of business. Therefore, some combination of wages and work rules must fall to keep the firm in business. I show that increasing competition reduces restrictive work rules. In turn, productivity increases.

I examine the impact of changes in competition on the measurement of productivity in the model. With market power, there are rents that are allocated among input providers. The presence of work rules in the model complicates the measurement of factor shares, which complicates the measurement of TFP. Measured capital shares will tend to be too low under monopoly. Competition reduces the degree of this mismeasurement.

I also examine the impact of demand shocks on work rules. Under normal circumstances, the workers can find employment for all its members and still charge a wage premium. In a small downturn, the wage premium that is feasible is reduced but employment can be maintained. In this case, there are wage concessions, but no concessions on work rules. This finding is consistent with the "concession bargaining" literature that finds that wage concessions occur in industries with a high degree of market power and are linked with industry performance.

In severe downturns, there is insufficient surplus to pursue both goals. Even without a wage premium, work rules would drive the firm out of business. Therefore, the workers adjust work rules to keep the firm in business. They are only willing to adjust work rules if it knows the firm is on the verge of closing.

Work rules can also have the effect of inducing resistance to new technology. Higher productivity increases demand for labor at a given wage, but also reduces the power of work rules to increase employment. When labor share is small or when demand is elastic, the work rule effect is stronger and employment would fall if the new technology was adopted. The union will only allow the adoption of the new technology if it is allowed to impose more work rules to maintain the employment that would otherwise be lost.

This paper is part of a theoretical literature examining productivity and labor unions, including Acemoglu, Aghion & Violante (2001) and Dowrick & Spencer (1994). Other papers have investigated the impact of labor unions on the decision to outsource work (Holmes & Snider 2009). This paper differs from previous work in that it analyzes unproductive work rules.

A related theoretical literature, drawing on the work of Olson (1982), has developed to explain why technological improvements are blocked[2]. 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 & Moro 2006), or inability of "winners" to organize (Bridgman, Livshits & MacGee 2007). This paper differs in that it examines why an existing technology would be operated inefficiently rather than why a new technology would be blocked.

2 Work Rules

Restrictive work rules have been a feature in many industries in the United States, including transportation, steel, mining, automobile manufacturing and newspapers. While work rules are imposed for a number of reasons, a number of them are restrictive, in that they lead to paid labor hours that do not produce output. This section provides evidence of such work rules.

At its most extreme, there are work rules requiring jobs that produce no output, sometimes referred to as featherbedding. Examples of this include the "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). There were referred to as witnesses since all they did was watch the loading without working at all. Another 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.

A common variety of wasteful work rule is limited substitutability of workers across multiple work categories. Such rules increase the amount of time on the job that a worker in not producing. In the West Coast longshore industry, there were a number of

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

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. Japanese-owned U.S. car plants have fewer job categories and are more productive than their U.S.-owned counterparts. Mitchell & 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. Schmitz (2005) documents the decline in the number of work categories in the iron ore industry after the crisis. Ichniowski (1984) finds that the number of pages in a labor contract is negatively correlated with productivity.

While many of these work rules are embodied in labor contracts, there are informal work rules. In the West Coast longshore industry, one practice was the "four on, four off" rule. Half the members of a gang would rest while the other half worked. (The name originates from a standard eight man hold loading gang). This practice persisted despite being explicitly banned by the labor contract. There were also informal maximum production limits. If a gang was getting ahead of its limit, they would delay calls for trucks to pick up cargo (Finlay 1987, Finlay 1988).

A crucial aspect of work rules for the theoretical results is they impose fixed costs of production. On the margin, the firm is using the technology efficiently but it has to pay for hours that are not used in production. It is true that many restrictive work rules are not strictly fixed costs, but are at least loosely related to output. The results require that the workers weaken the link between output and labor demand. A lot of the work rules generate downtime that is related to labor hired, but not in the linear way. For example, a Detroit Three auto plant must be operated in shifts: To make one car, the company must pay a full complement of workers for 8 hours. Within a shift, labor paid is fixed. The fixed cost assumption is a mathematically convenient way of breaking this link that allows for analytical solutions to the model.

The work rules that the paper studies do not cover all possible work rules. In contrast, there are work rules that increase costs but do not affect production, such as requiring the employer to provide hard hats. Rules may reduce productivity to accomplish another goal, such as worker safety or environmental protection. Others may make hours at work less productive. For example, in the U.S. bituminous coal industry, the United Mine Workers restricted the use of machinery causing unionized mines to use machinery less than non-union mines with similar characteristics (Boal & Pencavel 1994, Boal 1994). As we will see below, there may be an interaction between wasteful work rules and rules of this nature.

3 Model

3.1 Households

There is a continuum of households indexed by $i \in [0, 1]$. Each household is endowed with one unit of labor n_i. There is a continuum of goods c_j, indexed by $j \in [0, 1]$. Preferences are represented by the utility function:

$$U = [\int_0^1 c_j^{1-\rho}\theta_j dj]^{\frac{1}{1-\rho}}. \tag{3.1}$$

where θ_j is a demand shock for good j and $\rho \in (0, 1)$. Demand shocks only vary in industry 1. For $j \in [0, 1)$, $\theta_j = 1$.

3.2 Technology

Goods are produced using labor and capital according to the Cobb-Douglas production function:

$$c_j = (k_j)^{1-\alpha}(A_j n_j)^{1-\alpha}. \tag{3.2}$$

In all sectors, capital is hired at the competitive rental rate r. Each household owns a representative portfolio of shares in all firms and own the capital.

As in Chari & Hopenhayn (1991), more productive vintages of the technology arrive exogenously and can be costlessly adopted by firms. The productivity parameter A_j for vintage ν is given by $A_j = \gamma^{\nu}$ where $\gamma > 1$.

3.3 Monopoly Sector

The technology to produce good 1 is operated by a monopolist. Workers in the monopoly industry are represented by a union, whose membership is all incumbent workers ($\overline{n}_1$). When a worker exits the industry, she is no longer a member of the union.

The union can impose work rules on the production process of the monopoly firm, so that the production function becomes:

$$c_1 = (k_1)^{\alpha}(A_1 n_1 - \kappa)^{1-\alpha}. \tag{3.3}$$

where $\kappa > 0$.

The union sets the wage, work rules and vintage of the technology used by the firm. Similar to Pissarides (1986), it uses these instruments to maximize wages of its members, treating its members symmetrically.

The union's preferences are lexicographical: It wishes to maximize employment if employment is less than $\overline{n}_1$, the monopoly industry's incumbent workers. Once $n = \overline{n}_1$, it maximizes wages.

Given wage w_1, work rules κ and the technology A_1 the union selects, the monopolist chooses the amount of capital to rent and sets p_1 to maximize profits.

3.4 Foreign Sector

There is a foreign sector can sell same good as monopoly sector at price p^F. This sector can supply to whole market at this price. As a baseline, the foreign sector is not competitive: $p^F > p_1$. If it is competitive, the domestic monopoly prices according to Bertrand competition $p^F = p_1$. The severity of competition is indexed by p^F. A lower p^F means more severe competition. The interpretation is increasing competition represents falling trade barriers or the entry of low cost producers.

3.5 Goods and Labor Markets

All goods outside of the monopoly sector ($j \in [0, 1)$) are produced by competitive firms, where wages, rental rates and prices are set competitively. Competitive firms maximize profits taking prices p_j and wages w_j $j \in [0,1)$ as given and are not restricted from adopting new vintages.

3.6 Timing

The timing in the monopoly sector is as follows:

1. Demand parameter θ_1 is realized.
2. Union sets wage/technology/work rule policy.
3. Firm capital capital and sets price.
4. Production/consumption occurs.

4 Equilibrium

The state of the model at the beginning of the period is the measure of incumbent workers $\{\overline{n}_i\}_{j=0}^{1}$ and initial technologies $\{\overline{A}_j\}_{j=0}^{1}$ in each industry. Let $\mathcal{A}_j$ be the vintages of technology available for industry j.

Given prices and wages, households choose consumption maximize u subject to the budget constraint:

$$\int p_j c_j dj \leq \int w_j dj \tag{4.1}$$

The solution to this problem generates a demand function for the monopoly good $D(p_1)$.

The monopolist's problem is, given the wage, work rules and technology that it is allowed to use, to choose p_1 to solve:

$$\max_{p_1,k_1,n_1} \pi_1 = p_1 D(p_1) - w_1 n_1 - r k_1 \tag{4.2}$$

$$s.t.$$

$$D(p_1) = (k_1)^{\alpha}(A_1 n_1 - \kappa)^{1-\alpha} \tag{4.3}$$

$$p_1 \leq p^F \tag{4.4}$$

The solution to the firm's problem generates profits $\pi_1(w_1, A_1, \kappa)$ and labor demand $n_1(w_1, A_1, \kappa)$ that depend on the wage, work rules and technology selected by the union. If the firm cannot make positive profits, it does not operate.

The union's problem depends on whether there exists a union policy w_1, A_1, κ that allows full employment. If so, the union sets the wage as high as is consistent with full union employment and non-negative firm profit. It solves:

$$\max_{w_1,\kappa,A_1} w_1 \tag{4.5}$$

$$s.t.$$

$$\pi_1(w_1, A_1, \kappa) \geq 0 \tag{4.6}$$

$$n_1(w_1, A_1, \kappa) \geq \overline{n}_1 \tag{4.7}$$

$$A_1 \in \mathcal{A}_1 \tag{4.8}$$

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

$$\max_{w_1,\kappa,A_1} n_1 \tag{4.9}$$

$$s.t.$$

$$\pi_1(w_1, A_1, \kappa) \geq 0 \tag{4.10}$$

$$w_1 \geq w_0 \tag{4.11}$$

$$A_1 \in \mathcal{A}_1 \tag{4.12}$$

The definition of equilibrium is standard.

Definition 4.1. *An equilibrium is prices, wages, consumption, technology and industry assignments for workers such that:*

1. *Households solve their problem,*
2. *Firms solve their problem,*
3. *The union solves its problem,*
4. *Markets clear.*

5 Results

This section proceeds by first presenting the solution to and results for the monopoly case unconstrained by competition. Then I introduce binding competition and compare the two cases.

5.1 Monopoly Solution

Since we are concerned with the dynamics of the monopoly industry $i = 1$, I will concentrate on a symmetric equilibrium in the competitive industries. There is an initial distribution of workers in each industry: $\{\overline{n}_j\}_{i=0}^{1}$. All competitive industries start with the same initial measure of incumbent workers. For simplicity, I set these quantities to one: $\overline{n}_j = \overline{n}_{j'} = 1$ for $j, j' \in [0, 1)$. I also assume they use the same technology, also normalized to one: $A_j = A_{j'} = 1$ for $j, j' \in [0, 1)$. The wages in these industries are given by $w_j = p_j(1-\alpha)\frac{y_j}{n_j}$ and the rental rate is given by $r_j = p_j\alpha\frac{y_j}{k_j}$. Normalize the price of good 0 to 1. By symmetry, $p_j = 1$ for all $j \in [0, 1)$. For convenience, I will identify the quantities in the competitive industries by the subscript 0.

The model is solved backward. Since the monopoly industry is atomistic, the wealth of the representative household is given by the wage and capital returns in the competitive sector. Wealth is $A_0 = 1$. Therefore, the household's demand is

$$D(p_1) = [\frac{\theta_1}{p_1}]^{\frac{1}{\rho}} \tag{5.1}$$

Given this demand and the wage and technology that the union sets, the monopolist sets price:

$$p_1(w_1, r, A_1) = (\frac{w_1}{A_1})^{(1-\alpha)}(\frac{1}{1-\rho})r^{\alpha}[(\frac{\alpha}{1-\alpha})^{1-\alpha} + (\frac{1-\alpha}{\alpha})^{\alpha}] \tag{5.2}$$

The union selects wage, work rules and technology to maximize the wage subject to full employment and not driving the monopoly firm out of business. The union will choose κ and w_1 so that both constraints bind.

Assume that demand for the monopoly good is sufficient that full employment can be achieved at a wage above the competitive wage. The union will set the wage as high as is consistent with full union employment.

$$w_1^* = A_1[\frac{\theta_1^{\frac{1}{\rho}}}{A_1\overline{n}_1}(\frac{1}{r^\alpha})^{\frac{1-\rho}{\rho}}[(\frac{1-\alpha}{\alpha})^\alpha(1-\rho)^{\frac{1}{\rho}}\Psi^{\frac{1}{\rho}}+((1-\rho)^{\frac{1-\rho}{\rho}}-(1-\rho)^{\frac{1}{\rho}})\Psi^{\frac{1-\rho}{\rho}}]]^{\frac{\rho}{\alpha\rho+1-\alpha}} \quad (5.3)$$

where

$$\Psi = \frac{1}{(\frac{\alpha}{1-\alpha})^{1-\alpha}+(\frac{1-\alpha}{\alpha})^\alpha} \quad (5.4)$$

Work rules are given by:

$$\kappa^* = A_1\overline{n}_1\frac{((1-\rho)^{\frac{1-\rho}{\rho}}-(1-\rho)^{\frac{1}{\rho}})\Psi^{\frac{1-\rho}{\rho}}}{(\frac{1-\alpha}{\alpha})^\alpha(1-\rho)^{\frac{1}{\rho}}\Psi^{\frac{1}{\rho}}+((1-\rho)^{\frac{1-\rho}{\rho}}-(1-\rho)^{\frac{1}{\rho}})\Psi^{\frac{1-\rho}{\rho}}} \quad (5.5)$$

Adopting the new technology $A_1' = \gamma\overline{A}_1$ raises wages, so if it is available the new technology is adopted.

5.2 Rationale for Wasteful Work Rules

The theory provides an explanation for why workers would want to build in wasteful work rules. Work rules provide an instrument to keep wages high without driving employment down.

Without work rules, the union can only affect employment (for a given level of technology) by adjusting wages. As wages fall, the firm demands more labor. Therefore, increasing wages comes at the cost of employment. This effect can be seen clearly from the firm's labor demand function:

$$n(w_1,\kappa) = A_1^{\frac{(1-\alpha)(1-\rho)}{\rho}}(\frac{1}{w_1})^{\frac{\alpha\rho+1-\alpha}{\rho}}\theta_1^{\frac{1}{\rho}}(\frac{1}{r^\alpha})^{\frac{1-\rho}{\rho}}(\frac{1-\alpha}{\alpha})^\alpha(1-\rho)^{\frac{1}{\rho}}\Psi^{\frac{1}{\rho}}+\frac{\kappa}{A_1} \quad (5.6)$$

The union can counteract this effect by adding wasteful work rules since labor demand is increasing in work rules κ. When the union pushes up wages, it can counteract lower labor demand by increasing the wastefulness of the work rules.

This intuition carries over to the equilibrium allocations. 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 ($\kappa = 0$). Equilibrium wages in the model are higher than in the case where the union cannot use work rules. This result is formalized in the following proposition.

Proposition 5.1. *Assume that demand for the monopoly good is sufficient that full employment can be achieved at a wage above the competitive wage. Wages with work rules* w_1^* *are higher than wages without work rules* w_1^{NWR} *and employment is unchanged:* $n_1^* = n_1^{NWR} = \overline{n}_1$.

Proof. If the union did not have access to work rules as an instrument $\kappa = 0$, the union chooses the wage such that $n_1^{NWR} = \overline{n}_1$. This wage is given by:

$$w_1^{NWR} = A_1[\frac{\theta_1^{\frac{1}{\rho}}}{A_1\overline{n}_1}(\frac{1}{r^{\alpha}})^{\frac{1-\rho}{\rho}}(\frac{1-\alpha}{\alpha})^{\alpha}(1-\rho)^{\frac{1}{\rho}}\Psi^{\frac{1}{\rho}}]^{\frac{\rho}{\alpha\rho+1-\alpha}} \tag{5.7}$$

Comparing the wage with work rules (equation 5.3) and equation 5.7, wages with work rules are higher ($w_1^* > w_1^{NWR}$) if $(1-\rho)^{\frac{1-\rho}{\rho}} > (1-\rho)^{\frac{1}{\rho}}$. Simplifying, this condition becomes $(1-\rho)^{\rho} < 1$. Since $\rho \in (0,1)$, the expression is true. □

Work rules take the form of a fixed cost. An alternative way of imposing work rules would be to directly reduce productivity parameter A_1. The union would not want to use this form if the κ form is available. The fixed cost does not affect the firm's marginal pricing decisions. This fact can be seen by examining the pricing equation (Equation 5.2) and noting that κ does not appear. Reducing A_1, raises the price which in turn reduces households' demand for the monopoly good and the labor that produces it. Without work rules in the form of κ, labor demand (Equation 5.6) is strictly increasing in A_1.

Another method of increasing employment would be for the union to force the firm to use $\overline{n}_1$ workers in production and set wages. Given access to work rules, the union would not want to maintain employment in this way. This plan yields higher output than under work rules, which requires lower prices and lower surplus. The union prefers work rules that are wasteful since they do not interfere with the monopoly firm's marginal pricing problem and yield the largest surplus.

5.3 Impact of Work Rules on Productivity

Productivity is reduced by work rules. Clearly, work rules lead to labor being wasted which will reduce productivity.

Properly measured, total factor productivity (TFP) is given by:

$$\begin{aligned} \ln(TFP) &= \ln(y) - \alpha \ln(k) - (1-\alpha)\ln(n) \\ &= \alpha \ln(k) + (1-\alpha)\ln(An-\kappa) - \alpha \ln(k) - \ln(n) \end{aligned} \tag{5.8}$$

This expression simplifies to $(1-\alpha)(\ln(An-\kappa) - \ln(n))$. Without work rules, this expression collapses to $(1-\alpha)\ln(A)$. For a given level of inputs, it is clear that TFP declines as work rules become more restrictive (κ increases). This calculation assumes that TFP is properly measured. Below, I discuss the problems of productivity measurement with work rules.

Since work rules introduce a fixed cost, the production function becomes increasing returns to scale. For a given κ, TFP falls if labor input falls. In the full employment equilibrium, labor input does not change so scale is not an issue. When full employment is not sustainable (the crisis equilibrium analyzed below), scale may impact TFP measurement.

Productivity is higher when labor share is higher and when demand is inelastic. Note that the source of inefficiency is not resistance to new technology (improvements in A) but the inefficient use of that technology. As can be seen in Equation 5.5 work rules are stronger when capital share is higher and when demand is elastic. The first observation is consistent with the observation that the industries with the most restrictive work rules tend to be capital intensive industries, such as steel.

The presence of market power introduces the possibility of mismeasurement of factor shares. Work rules allow the workers to capture all the rents associated with market power. Capital owners only receive the market rental rate of capital. I discuss the impact of market power on TFP measurement below.

5.4 Wage Concessions

Union's emphasis on protecting the employment of its members means that it will be willing to give wage concessions to maintain employment during downturns. Wages chosen by the union (Equation 5.3) are a linear function of the demand shock θ_1. Equation 5.3 only applies when the union can still command a wage premium, so this analysis only applies when downturns are relatively small. Below I consider strong downturns, crises when a wage premium cannot be sustained.

This finding is consistent with findings of the concession bargaining literature. Freeman & 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 where union contracts were renegotiated in advance of their expiration date. Generally, unions accepted wage cuts during poor economic times in exchange for employment guarantees. Greenberg (1968) finds that union locals are willing to violate the wage terms of their master contract (accept lower wages) to preserve employment.

Note that the union does not give concessions on work rules. The union's work rule decision is not dependent on market conditions (Equation 5.5), again assuming that demand is high enough. Therefore, wages are cut but productivity is unchanged in minor downturns.

5.5 Competition and Work Rules

I now introduce binding competition to the monopoly sector. Competition reduces work rules and increases productivity.

There are two types of competition: crisis and non-crisis. Crisis competition is the case where p^F is low enough that full employment and wage premium cannot be maintained. Non-crisis competition is the case where p^F is below the monopoly price but high enough that both full employment and wage premium can be maintained. In both cases, competition leads to increased productivity by reducing work rules. However, the mechanism is somewhat different in the two cases since the union is in different regions of its lexicographical preferences.

When comparing the equilibrium work rules for a set of parameters under monopoly and non-crisis competition, work rules are lower and productivity higher under competition. Let $\kappa(p)$ be the work rules associated with price p. Let p^C be the cutoff price such that if $p^F < p^C$ a full employment equilibrium does not exist.

Proposition 5.2. *Work rules under competition are lower than under monopoly:* $\kappa(p_1^*) > \kappa(p^F)$ *where* $p_1^* > p^F > p^C$.

Proof. Since profits are zero in the monopoly case, profits are negative under competition with monopoly wages and work rules. Therefore, under the new equilibrium, wages or work rules must fall to satisfy the non-negative profit constraint. Note that labor demand for a given wage increases since the lower price leads to more demand. To satisfy the full employment constraint, employment must be reduced. Since lower wages increase labor demand, work rules must fall.

□

Since work rules fall while employment is constant, TFP is higher under non-crisis competition compared to the unconstrained monopoly.

The same result holds for degrees of non-crisis competition. If $p_1^* > p^F > p^{F,\prime} > p^C$, then $\kappa(p^{F,\prime}) < \kappa(p^F)$. The proof proceeds in the same way as Proposition 5.2.

In the above analysis, the union can command both full employment and a wage premium. However, when competition is severe these twin goals cannot jointly be pursued. The union wishes to maintain as much employment as possible. To keep workers in the industry, it must set a wage that is competitive with alternative industries ($w_1 \geq w_0$) or workers will abandon industry 1 for employment in non-monopoly industries. It must still ensure that the firm makes sufficient profits so that it will operate in the monopoly sector. The union's problem shifts from maximizing wages subject to full employment to maximizing employment at the wage of the outside option. The union will set work rules at the highest level that is consistent with the firm operating in the monopoly industry.

The crisis work rules solution is:

$$\kappa^{Crisis} = \frac{A_1}{w_0}\theta_1^{\frac{1}{\rho}}(p^F)^{\frac{1-\rho}{\rho}} - (\frac{A_1}{w_0})^{\alpha}(\frac{\theta_1}{w_0})^{\frac{1}{\rho}}r^{\alpha}\frac{1}{\Psi} \tag{5.9}$$

In the crisis mode, more severe competition (lower p^F) induces fewer work rules. As a consequence, productivity improves with the severity of the crisis. From Equation 5.8, TFP is driven by the ratio of output from labor to labor input:

$$\frac{An - \kappa}{n} = \frac{(\frac{r(1-\alpha)}{\alpha w_0})^{\alpha}}{\frac{p^F}{\theta_1 w_0} - (\frac{r}{w_0})^{\alpha}(\frac{\alpha}{1-\alpha})^{1-\alpha}} \tag{5.10}$$

As p^F declines, this ratio increases. Therefore, TFP increases with the severity of competition.

5.5.1 Demand Crises

Just as competition can make full employment and a wage premium for the union impossible, a large decline in demand (θ_1) can have the same effect. Similar to the competition crisis case, the union adjusts work rules to maximize employment at the competitive wage w_0.

The demand crisis work rules are:

$$\kappa^{DC} = \theta^{\frac{1}{\rho}} (\frac{A_1}{w_0})^{\frac{\alpha\rho+1-\alpha}{\rho}} ((1-\rho)^{\frac{1-\rho}{\rho}} - (1-\rho)^{\frac{1}{\rho}})(\frac{\Psi}{r^{\alpha}})^{\frac{1-\rho}{\rho}} \tag{5.11}$$

While demand crises reduce work rules, they do not have the same impact on productivity. The ratio of outputs due to labor to labor input is:

$$\frac{A_1 n_1^{DC} - \kappa^{DC}}{n_1^{DC}} = A_1 - \frac{((1-\rho)^{\frac{1-\rho}{\rho}} - (1-\rho)^{\frac{1}{\rho}})\Psi^{\frac{1-\rho}{\rho}}}{((1-\rho)^{\frac{1-\rho}{\rho}} - (1-\rho)^{\frac{1}{\rho}})\Psi^{\frac{1-\rho}{\rho}} + \frac{1}{A_1}(\frac{1-\alpha}{\alpha})^{\alpha}(\Psi(1-\rho))^{\frac{1}{\rho}}} \tag{5.12}$$

TFP does not increase with a demand crisis even though work rules decline. The fixed cost generates increasing returns to scale. Producing at a smaller scale for a given fixed cost reduces TFP. While there is less wasted labor input, which increases TFP, employment is falling. The two forces exactly counter each other, leaving TFP unchanged.

5.6 Compensation for Work Rules?

Given that they are inefficient, could the work rules be removed by an agreement between the union and the firm?

If $w_1^{NWR} \geq w_o$, a compensation package is possible. There exist transfers that provide the same level of employment and payments to workers as the work rules case while increasing profits to the firm. However, if $w_1^{NWR} < w_o$, it is impossible to have both a wage premium and full employment without work rules.

The no-compensation case $w_1^{NWR} < w_o$ applies if $\overline{n}_1$ is large, since there are too many workers to employ given the level of market power.

Paradoxically, this condition also applies if the firm has a high degree of market power due to 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. In this case, work rules are important (κ is large) since they allow the (large) monopoly profits to be captured by the union. Removing work rules reduces employment significantly, so wages must fall sharply to counteract the loss of labor demand.

5.7 Measurement of TFP

Up to this point, I have used the exact measurement of TFP. However, the presence of market power complicates measurement for analysts that do not know the production function. Productivity measurement with market power is a well known issue.

Let $\hat{\alpha}$ be measured capital share. Measured TFP will be:

$$\begin{aligned}\Delta\ln(T\hat{F}P) = \alpha[\ln(k_t) - \ln(k_{t-1})] - \hat{\alpha}[\ln(k_t) - \ln(k_{t-1})] + \\ (1-\alpha)[\ln(A_t n_t - \kappa_t) - \ln(A_{t-1}n_{t-1} - \kappa_{t-1})] - (1-\hat{\alpha})[\ln(n_t) - \ln(n_{t-1})]\end{aligned}$$

Due to market power, $\hat{\alpha} < \alpha$. Let η be labor's mark-up over the true labor share: $1-\hat{\alpha} = 1-\alpha+\eta$. TFP growth becomes:

$$\begin{aligned}\Delta\ln(T\hat{F}P) = \eta[\ln(k_t) - \ln(k_{t-1})] + (1-\alpha)[\ln(A_t n_t - \kappa_t) - \ln(n_t) - \ln(A_{t-1}n_{t-1} - \kappa_{t-1}) + \ln(n_{t-1})] \\ - \eta[\ln(n_t) - \ln(n_{t-1})]\end{aligned}$$

The mismeasurement that market power introduces is:

$$\Delta\ln(T\hat{F}P) - \Delta\ln(TFP) = \eta[\ln(k_t) - \ln(k_{t-1}) - \ln(n_t) + \ln(n_{t-1})]$$

This mismeasurement is decreasing in labor growth and increasing in capital growth. Since measured capital share is too low, too little capital growth is subtracted off output growth. The opposite occurs with labor growth. In addition, the degree of mismeasurement changes with the degree of competition and due to demand shocks.

The labor share under monopoly case is:

$$LS^M = (\theta_1^{\frac{1}{\rho}}\overline{n}_1 r^{\frac{\alpha(1-\rho)}{\rho}})^{\frac{(1-\alpha)(1-\rho)}{\alpha\rho+1-\alpha}}(\frac{\Psi}{1-\rho})^{\frac{(1-\rho)}{\rho}}[((1-\rho)^{\frac{1-\rho}{\rho}} - (1-\rho)^{\frac{1}{\rho}})\Psi^{\frac{1-\rho}{\rho}} + (\frac{1-\alpha}{\alpha})^{\alpha}(\Psi(1-\rho))^{\frac{1}{\rho}}]^{\frac{\rho}{\alpha\rho+1-\alpha}} \tag{5.13}$$

Therefore η increases with demand in the monopoly case under normal demand since LS^M is an increasing function of the demand parameter θ. A positive demand shock in this case will lead to an increase in capital hired but no increase in labor hired. Therefore, the mismeasurement will be positive and increasing as demand increases.

The market power of the union is negatively related to true productivity growth: η declines as competition - and productivity - increase. Under a competitive crisis, the labor share is:

$$LS^C = \frac{w_0}{A_1}(p^F)^{\frac{1-\rho}{\rho}}\theta_1^{\frac{1}{\rho}}[(\frac{A_1}{w_0})^{\frac{\alpha\rho+1-\alpha}{\rho}}\theta_1^{\frac{1}{\rho}}(\frac{1}{r^\alpha})^{\frac{1-\rho}{\rho}}(\frac{1-\alpha}{\alpha})^\alpha(1-\rho)^{\frac{1}{\rho}}\Psi^{\frac{1}{\rho}} + \kappa^{Crisis}] \tag{5.14}$$

Since κ^{Crisis} falls as p^F falls, the labor share falls as competition becomes more severe.

As labor's productivity is increasing due to reduced work rules, the weight that labor gets in calculating TFP falls.

5.8 Resistance to New Technology

If a new technology is available, the union will always allow the adoption new vintages. However, the presence of work rules can induce resistance to adopting new vintages unless the union has control over how the new technology is operated. Without work rules, new technology is supported by both the union and firms since it increases profits for firms and wages and labor demand for the union. These forces are still in operation with work rules, but there is a countervailing force. New technology weakens the impact of work rules, reducing the demand for labor. In some cases, the fall in labor demand from the work rule weakening force is stronger than the increase in labor demand from the new technology.

To examine this situation, suppose that the monopoly firm wished to adopt a new technology under wages and work rules implied by the old technology. The following proposition establishes conditions under which the union would block adoption.

Proposition 5.3. *For any γ,*

1. *For every α, there exists $\overline{\rho}$ such that technology adoption is blocked for all $\rho > \overline{\rho}$*
2. *For every ρ, there exists $\overline{\alpha}$ such that technology adoption is blocked for all $\alpha > \overline{\alpha}$*

Proof. The new technology will reduce employment if:

$$\gamma^{\frac{1}{1-(1-\alpha)(1-\rho)}}(1-\alpha)(1-\rho)+1-(1-\alpha)(1-\rho)\leq\gamma \tag{5.15}$$

The limit of the RHS of Equation 5.15 is zero as $\rho \to 1$ for a given α and $\alpha \to 1$ for a given ρ . □

The union will always accept the new technology in equilibrium since it can adjust the work rules (increase κ) to compensate for the fall in labor demand. Just increasing wages is insufficient to garner union support, since that change will not lead to full employment for union members. In fact, raising wages exacerbates the problem by reducing labor demand further.

This finding is consistent with the data. If the union can dictate work rules without restriction, it is willing to adopt the new technology. An example is the bulk loading witnesses in Pacific ports discussed above. The ILWU accepted the new bulk loading methods without a fight since it could dictate minimum gang size. If the union could not increase work rules to compensate for the loss of employment, under the conditions of the proposition, the union would oppose the new technology.

5.9 Discussion

In the model, there is a single monopoly firm. In examples of work rules given above, there are usually a number of firms. As long as the union can impose the same rules across firms and there is no entry, the results hold up. Suppose the monopoly was divided into two firms. Neither firm would wish to deviate from the monopoly price since it would lead to profits below the value of operating in the competitive sector. As has been noted in the cartel literature, maintaining cooperative cartel behavior is easier when costs are similar (Vasconcelos 2005). In a number of cases, unions have explicitly pursued common wages and work rules across firms. As documented by Hoerr (1988), 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. Such unified contracts across firms were also found with port labor and coal mining.

The results do 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 workers utility would likely strengthen the results. The union will resist eliminating work rules more if workers get utility from working less hard.

In fact, unions tend to fight for firm-provided pensions for early retirement. In many of the cases mentioned above- such as autos, coal mining and steel - the union has negotiated retirement at 30 years of service regardless of age. Moving workers to pensions has the same effect of generating a fixed labor cost that is not used in production.

Why aren't all excess workers pensioned out instead of kept at work? It can be difficult to justify payments to prime aged 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). Firms may have difficulty committing to deals that are politically unpopular and unions may be suspicious that the firms will use public pressure to get out of their obligations in the future.

Another factor is that workers that are split between workers and pensioners may be difficult for the union to organize. If there is a significant stock of members who do not work, there may be a conflict over what goals the union should pursue. Retirees will want high benefits and have little interest in high wages or maintaining employment while current workers will weight the latter goals more highly. This conflict has occurred in the past. The United Mine Workers developed a situation where a majority of its members did not work as miners. Labor contracts had to be ratified by a group where most members did not work. Further, it may be difficult for union members to communicate and coordinate if workers and pensioners are in different places.

6 Conclusion

This paper gives an explanation for genuinely wasteful work rules in non-competitive industries. While the model is highly stylized, the basic mechanism that it identifies is likely to hold in less restrictive environments. The feature that higher wages reduce labor demand is a nearly universal feature. Adding non-productive paid work hours allows workers to maintain employment while keeping wages high.

There are a number of future directions to take the analysis. One potentially interesting avenue is to increase the number of firms. The possibility of work rules may make collusion more sustainable and affect the industrial organization of oligopoly industries.

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