Outsourcing to Limit Rent Extraction

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1 Introduction

In the 1920s, Henry Ford famously built a factory in which the raw materials for steel came in on one end and finished automobiles came out the other. But extreme vertical integration such as this is not the fashion today. Ford Motor has recently spun off a significant portion of its parts making operations as a separate company and General Motors has done the same. While General Motors has not attempted to spin off final assembly plants, they are currently trying to outsource to outside contractors the janitorial services within an assembly plant as well as forklift operations. Northwest Airlines has recently begun outsourcing the cleaning of airplanes to outside contractors.

The mantra underlying much of the discussion about outsourcing by business consultants is that companies need to focus on their *core competencies* and they should consider outsourcing the rest. This idea of specializing according to comparative advantage would be very familiar to Ricardo. Surely comparative advantage based on production efficiency is a major force behind outsourcing. But it is not the only force and it has little to do with why General Motors wants to outsource janitorial services. GM's motivation is no secret and is not disputed: Janitors who work for General Motors are members of the United Auto Workers and they get a union salary of $28 an hour; janitors through an outside contractor would receive approximately $12.[1] Analogously, Northwest Airlines is hiring outside contractors to clean airplanes because the contractors' wages are lower than the union wages Northwest would be paying if they did the job themselves.

This paper develops a theory of outsourcing in which the circumstances under which factors of production can grab rents plays the leading role. One factor has some monopoly power (call this *labor*) while a second factor does not (call this *capital*). There are two stages of production, a labor intensive task and a capital intensive task. All firms are the same in *core competencies* and a transaction friction is incurred when the two tasks are not integrated in the same firm. So in the absence of any monopoly power by labor, all firms are completely integrated doing the labor intensive and capital intensive tasks in the same facility, to avoid the transaction friction. But if labor has monopoly power and if the transactions friction is not prohibitively large, there is vertical disintegration with some firms specializing in the labor intensive task and other firms specializing in the capital intensive task.

Now if there is heterogeneity among firms in their ability to negotiate with workers, e.g.

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[1]See "GM to UAW: Let's cut costs," *Workforce Management: News in Brief*, April 16, 2007.

some firms are ex ante union, some ex ante nonunion, it is straightforward to see that there should be specialization of some kind when there are small transactions frictions. Firms would specialize according to their comparative advantage in dealing with labor. Our surprising result is that even when firms are homogeneous in their ability to negotiate with workers specialization necessarily obtains in equilibrium. When the two activities are split up there is a tradeoff. Firms that specialize in the labor intensive task pay lower wages than if they were vertically integrated, because their high labor share makes them sensitive to wage changes; i.e. labor demand is more elastic. Offsetting this is that firms that specialize in the capital intensive task pay higher wages since their labor demand is less elastic. So the vertical disintegration of activity tends to drive down the cost of the labor intensive component and drive up the cost of the capital intensive component. Our finding is that the net effect of vertical disintegration on total labor costs is negative and this is why disintegration takes place when transactions costs are small.

Our next set of results concern what happens when firms are ex ante heterogeneous with some union and some nonunion. If there is specialization by firm type, what is the pattern of trade? We find that if the nonunion firms are trading with the union firms, the nonunion firms are specializing in the labor intensive task. This is an intuitive result and is consistent with the facts (e.g. auto parts is labor intensive and is nonunion, assembly is capital intensive and union). There are subtleties in the proof of the result. When a union firm does the capital intensive task it ends up paying extremely high wages. So the wage advantage of a nonunion firm over a union firm is actually bigger for the capital intensive task than the labor intensive task. But the labor share difference in the two tasks dominates the wage effect, leading the nonunion firms to specialize in the labor intensive task.

There is a growing recent literature on outsourcing in the context of international trade where it is called offshoring. Papers such as Antras, Garicano, and Rossi-Hansberg (2006) and Helpman and Rossi-Hansberg (2006) highlight specialization based on comparative advantage. Another recent literature examines how information flows affect integration decisions (Alonso, Dessein and Matouschek (2006), Friebel and Raith (2006)).

The largest literature on the subject focuses on how incomplete contracts and relationship-specific investment affect the organization of the firm. The early literature (Williamson (1979)) focused on how the choice of the organization of the firm determines possibilities for ex post opportunistic behavior. A supplier making an investment specific to an upstream producer needs to worry about being "held up" after the fact. Klein, Crawford, and Alchian (1978) made famous the 1926 merger of General Motors with Fisher Body as an example

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of what they argued was a vertical merger to eliminate holdup. Our paper follows this literature in that how firms are organized affects the opportunities for rent extraction. The difference here is that integration doesn't necessarily eliminate opportunistic behavior, it can potentially increase it. Certain factors of production may be in a better position to grab rents within the boundaries of the firm than outside the boundaries. On this point, it is worth noting the argument by Freeland (2000) that after GM acquired Fisher Body, it put the Fisher brothers who were now employees of GM in a better position to grab rents from GM that they exploited.

The subsequent literature on incomplete contracts focused on how the allocation of property rights affects ex ante investment incentives (Grossman and Hart (1986), Hart and Moore (1990)). In our analysis, we can think of the choice to be vertically disintegrated as an investment. If all residual rights of control can be allocated to the labor union *before* decisions are made about vertical disintegration then the first best is obtained where there is no outsourcing and no transaction friction incurred. Put in another way, if the union owned the firm, nothing interesting would happen in our model. We abstract from this possibility and we appeal to institutional features of labor law for justification. We argue that if one union took ownership of a firm and began to operate it like a profit-maximizing enterprise, it would get voted out by workers. Essential in our analysis is a commitment problem. There is no way for workers to commit in advance not to try to extract rents. Outsourcing is a way to address the commitment problem.

This paper is related to the literature on price discrimination with competition. When firms are vertically integrated, the union offers a uniform price for labor used in the two tasks. When firms are specialized, the price of labor depends upon what task labor does. The finding that unions in equilibrium are worse of with vertical disintegration is analogous to the finding in Holmes (1989) and Corts (1998) for how competing firms can be worse off when price discrimination is feasible.

While more work needs to be done, the existing empirical evidence suggests that limiting rent extraction is a significant factor behind important components of outsourcing activity. The contract cleaning industry mentioned above in the context of General Motors and Northwest Airlines is a good place to start looking for this factor. Abraham (1990) shows that building service employees employed in the business service sector (e.g. contract cleaning firms) receive substantially lower wages and benefits than the employees doing the same jobs employed by manufacturing firms. And Abraham and Taylor (1996) show that it is the higher wage firms who are more likely to contract out cleaning services. They don't find

a connection between unionization and tendency to outsource, but they note that a union might be powerful enough to prevent a firm from doing the outsourcing they otherwise would want to do. The fact that General Motors is currently paying workers $28 an hour to do janitorial work is evidence on this point. In contrast to Abraham and Taylor, Autor (2003) does find a positive connection between outsourcing and unionism. He finds that states with slower declines in unionism have had more rapid growth in temporary help services. There is also evidence for specific industries. Forbes and Lederman (2005) discuss how airlines spin off short routes to regional airlines because the pilots of these airlines are less able to extract rents. Doellgast and Greer (2007) provide a case study of the German automobile industry for how outsourcing parts has cut rents. We don't know of such a study for the U.S. automobile industry but since General Motors has spun off its Delphi parts operations, Delphi is trying to cut "wages from as much as $30 an hour to as little as $10 an hour."[2]. GM spun off American Axel in 1992. This automobile supplier is currently in the middle of a strike where it is attempting to cut wages and benefits by about half.

2   Model

We model an industry in which a final good is made in two steps, one producing a labor intensive intermediate good (good 1) and the other producing a capital intensive intermediate good (good 2). A firm may be vertically integrated and execute both steps itself, or it may be specialized in the production of either intermediate good. Each intermediate good q_i, for $i = 1, 2$, is made with the following technology

$$q_i = y_i \left(y_1 + y_2\right)^{-(1-\gamma)}. \tag{1}$$

The variable y_i is called the level of production activity of input i at a particular firm. This is the measure of activity before any diminishing returns sets in. The parameter γ governs the degree of diminishing returns. Now if γ were to equal one, then y_i would just equal q_i. Instead we set $\gamma \in (0, 1)$ and this gives diminishing returns in the conversion of production activity to completed intermediate output. Note the diminishing returns to scale applies to the sum of the firm's activities in the two intermediate goods. We include the diminishing returns to pin down firm sizes. If in the way we modeled diminishing returns, we put

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in economies of scope or diseconomies of scope in the production of the two inputs, these modeling assumptions would directly influence the choice of firm structure. By running the diminishing returns through the sum of the firm's activities, we keep things neutral and it would have no bearing on the choice of firm structure in a world without unions.

The production activity level y_i depends upon the capital k and labor l allocated to the activity as follows

$$y_i = f_i(k, l) = \frac{1}{\alpha_i^{\alpha_i} (1 - \alpha_i)^{1-\alpha_i}} l^{\alpha_i} k^{1-\alpha_i}. \tag{2}$$

Note at the level of the production activity y_i there is constant returns to scale. For simplicity we assume that the intensities are symmetric for the two intermediates,

$$\alpha_2 = 1 - \alpha_1.$$

Intermediate 1 is labor intensive so

$$\alpha_1 > \frac{1}{2}$$

so intermediate 2 is capital intensive,

$$\alpha_2 < \frac{1}{2}.$$

The final good results from combining the two completed intermediate goods, according to a the fixed-proportions technology. If the two inputs q_1 and q_2 are produced in a vertically-integrated firm, then output equals

$$q_f = f_{VI}(q_1, q_2) = \min\{q_1, q_2\}. \tag{3}$$

If the inputs are produced by two specialist firms then final good output is

$$q_f = f_S(q_1, q_2) = (1 - \tau) \min\{q_1, q_2\}.$$

The parameter τ can be thought of as some kind of transactions cost that must be borne when the intermediate inputs are produced at two different firms. Note it is in units of final consumption good.

There is a perfectly elastic supply of labor and capital to the industry. Let capital be the numeraire good with price $r = 1$. Let w° be the exogenous wage at which labor is supplied to the industry. The exogenous price of the final good is denoted p_f.

A firm can be union or nonunion. A nonunion firm can buy labor at the market rate w° (and capital at the market rate $r = 1$). A union firm can procure capital at the market rate of $r = 1$ but is subject to a monopoly supplier of labor. This labor monopoly operates at the level of a particular firm not the industry. The union at a particular firm can buy labor on the open market at w° and offers to sell labor to the firm at wage w. The firm makes its input choice given w. This setup is called the "right-to-manage" model in the labor literature.

There is a unit measure of firms indexed by $j \in [0, 1]$. Suppose firms $j \in [0, \phi]$ are nonunion and firms $j \in (\phi, 1]$ are union, so the nonunion share is ϕ.

The timing works as follows. Firms know their type, union or nonunion, at the beginning. There are three stages. In stage 1, each firm commits to one of three structures: vertically integrated, specialist producer of intermediate 1, or specialist producer of intermediate 2. In stage 2, if firm j is union, the the labor monopolist at the firm sets the wage w_j at the firm, otherwise it faces the market wage $w_j = w^\circ$. In stage 3, with wages set, the firms make input and output decisions and trade in intermediate goods takes place on the open market.

The definition of equilibrium in this economy is straightforward. It consists of a vector of union wage levels and intermediate input prices $(w_1^u, w_2^u, w_{VI}^u, p_1, p_2)$ and a decision rule for firm j of what firm structure to adopt (VI or specialist in intermediate 1 or specialist in intermediate 2) such that the firm's structure adoption decision is optimal given the wages it expects to get, union wage setting is optimal given firm input demands, and there is market clearing in the intermediate input market. Furthermore, the following arbitrage condition is satisfied,

$$p_1 + p_2 = (1 - \tau) \, p_f, \tag{4}$$

since combining one unit of each of the specialist produced goods yields $1 - \tau$ units of final good.

3 Union Wages and Costs

It is possible to solve for equilibrium union wages without taking into account equilibrium conditions in the output markets. This section solves for these wages and also derives the cost of production activity and how they depend upon vertical structure and union and nonunion status.

We begin with the simplest case of the specialist. Suppose we are at stage 3 and a specialist producer of intermediate input i faces a wage of w_i. The firm faces an output price of p_i and has a labor share coefficient of α_i. For simplicity, drop the i subscript for now. To begin to study the firm's choice problem, it is useful first to determine the cost function of attaining a level of production activity y (recall this is the activity level before we run it through the diminishing returns (1)). Given the constant returns Cobb-Douglas production function (2), it is a standard result that the cost function equals

$$c(w, y) = w^\alpha r^{1-\alpha} y = w^\alpha y, \tag{5}$$

noting the normalization that $r = 1$. The cost minimizing labor input choice is

$$l(w, y) = \alpha w^{-(1-\alpha)} y \tag{6}$$

From (1), a specialist producer attaining activity level y of one intermediate and 0 of the other produces y^γ of the first intermediate. Letting p be the price of the intermediate, profit given y equals

$$\pi(y) = p y^\gamma - w^\alpha y. \tag{7}$$

Setting y to maximize profit yields the optimal choice of activity y

$$y = (p\gamma)^{\frac{1}{1-\gamma}} w^{-\frac{\alpha}{1-\gamma}} \tag{8}$$

Plugging this into (6) yields the firm's labor demand

$$l^D(w) = \alpha \, (p\gamma)^{\frac{1}{1-\gamma}} \, w^{-\varepsilon}$$

for constant elasticity

$$\varepsilon(\alpha) \equiv \frac{1 - (1-\alpha)\gamma}{1-\gamma} \tag{9}$$

The elasticity of labor demand depends upon the output curvature parameter γ as well as the labor share coefficient α. The larger is α, the more elastic the labor demand.

With firm behavior pinned down, we now go backwards and examine the problem of the

labor monopolist in stage 2 picking w. The labor monopolist sets w to maximize

$$(w - w^\circ) \, l^D(w).$$

The labor monopolist obtains labor at the competitive rate w° and posts a wage w to the firm. Note the monopoly operates at the firm level, not the industry level. If the monopoly worked at the industry level, it would take into account the impact of wage on the output market. Working at the firm level, the labor monopolist takes output prices as fixed. Since labor demand is constant elasticity, the profit maximizing wage satisfies the standard monopoly markup over marginal cost condition

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\begin{aligned}
w_i^u &= \frac{1}{1 - \frac{1}{\varepsilon(\alpha_i)}} w^\circ & (10) \\
&= \frac{1 - (1 - \alpha_i)\,\gamma}{\alpha_i \gamma} w^\circ, & (11)
\end{aligned}
$$

where it is now a good time to revert including the subscript i to denote intermediate good i. Since $\alpha_1 > \alpha_2$, labor demand is more elastic for the labor intensive intermediate so $w_1 < w_2$.

We turn next to wage setting for a vertically-integrated firm. Given the fixed coefficient technology for the final good, such a firm needs to make an equal amount of both intermediate inputs. Let y be the production activity level of each intermediate. Given w, the cost of producing both intermediates at this level is

$$c_{VI}(w, y) = w^{\alpha_1} y + w^{\alpha_2} y = (w^{\alpha_1} + w^{\alpha_2})\, y. \qquad (12)$$

Now at production activity levels $y = y_1 = y_2$, from (1) the amount of intermediate input 1 produced is

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\begin{aligned}
q_1 &= y_1 \, (y_1 + y_2)^{-(1-\gamma)} \\
&= y \, (2y)^{-(1-\gamma)} = 2^{-(1-\gamma)} y^\gamma.
\end{aligned}
$$

And similarly this amount of q_2 is produced and hence this same amount of final good. The firm's profit is

$$p_f 2^{-(1-\gamma)} y^\gamma - (w^{\alpha_1} + w^{\alpha_2})\, y. \qquad (13)$$

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From (6), labor demand added up over both intermediate goods, given y equals

$$l = \alpha_1 w^{-(1-\alpha_1)} y + \alpha_2 w^{-(1-\alpha_2)} y \tag{14}$$

Maximizing (13) with respect to the choice of y and then plugging y in (14) yields the labor demand function faced by the union

$$l_{VI}^D(w) = \left(p_f 2^{-(1-\gamma)} \gamma\right)^{\frac{1}{1-\gamma}} \left(\alpha_1 w^{-(1-\alpha_1)} + \alpha_2 w^{-(1-\alpha_2)}\right) \left(w^{\alpha_1} + w^{\alpha_2}\right)^{-\frac{1}{1-\gamma}}$$

The union facing a vertically integrated firm picks w to maximize

$$\left(w - w^\circ\right) l_{VI}^D(w)$$

Let $w_{VI}(\alpha_1, \gamma, w^\circ)$ denote the solution. The appendix derives the first-order condition. In general, no analytic solution exists. However, we can obtain an expression for the limiting case where α_1 goes to 1 (and $\alpha_2 = 1 - \alpha_1$ goes to zero.). In this case

$$\lim_{\alpha_1 \to 1} w_{VI}^u = \frac{1 - \gamma + w^\circ}{\gamma}$$

By way of comparison, the union prices to specialist firms from (10) near this limit are

$$\lim_{\alpha_1 \to 1} w_1^u = \frac{1}{\gamma} w^\circ$$
$$\lim_{\alpha_1 \to 1} w_2^u = \infty.$$

This follows because the elasticity in intermediate 1 goes to $\frac{1}{1-\gamma}$ while it goes to 1 for intermediate 2. In terms of wages, we see that moving from vertical integration to specialization lowers the wage for intermediate 1 and raises the wage of intermediate 2. So there are conflicting effects on cost.

A key result that plays an important role in the subsequent analysis is that the net effect on costs of the specialization structure under unions is strictly less than under vertical integration. Let $c_{i,VI}^u$ and $c_{i,S}^u$ be cost of producing one unit of intermediate activity i at the union wages. Note that if $\alpha_1 = \alpha_2 = \frac{1}{2}$, the two intermediates are the same in elasticity and there is no difference between the specialization structure and vertical integration in

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terms of union wage setting behavior; i.e. $c_{i,VI}^u = c_{i,S}^u$. In the case where $\alpha_1 > \frac{1}{2}$, there is a difference. We show this analytically near the limit where α_1 is close to one and numerically for the rest of the parameter space. Finally, let $c_{VI}^u = c_{1,VI}^u + c_{2,VI}^u$ be the combined cost to the vertically integrated union form of one unit of each activity.

Lemma 1.

$$\lim_{\alpha_1 \to 1} \left[c_{1,S}^u + c_{2,S}^u \right] < \lim_{\alpha_1 \to 1} c_{VI}^u$$

Proof. See appendix.

Result 1. Straightforward numerical calculations over a fine grid over $\gamma \in (0,1)$, $w^\circ \in [.01, 100]$, and $\alpha_1 \in (.5, 1)$ verify that

$$\left[c_{1,S}^u + c_{2,S}^u \right] < c_{VI}^u. \tag{15}$$

In the analytic results reported below, we take as given that (15) holds.

4   Equilibrium Vertical Structure

In this section we determine equilibrium vertical structure. We focus on how it depends upon the distribution of the union probability and on the transactions cost τ. We begin with the interesting special case where all firms are union.

Proposition 1. Assume all firms are union, (so the nonunion share $\phi = 0$). There exists a $\hat{\tau} > 0$, such that if $\tau < \hat{\tau}$, all firms are specialized while if $\tau > \hat{\tau}$, all firms are vertically integrated.

Proof. Given an output price p_i and cost activity cost c_i^u of a union specialist in intermediate i, it is straightforward to derive its maximized profit,

$$\pi_i^u = \left[\gamma^{\frac{\gamma}{1-\gamma}} - \gamma^{\frac{1}{1-\gamma}} \right] p_i^{\frac{1}{1-\gamma}} \left(c_i^u \right)^{-\frac{\gamma}{1-\gamma}}. \tag{16}$$

Analogously, using (13), the profit of a vertically integrated union firm equals

$$\pi_{VI}^u = \frac{1}{2} \left[\gamma^{\frac{\gamma}{1-\gamma}} - \gamma^{\frac{1}{1-\gamma}} \right] p_f^{\frac{1}{1-\gamma}} \left(c_{VI}^u \right)^{-\frac{\gamma}{1-\gamma}}$$

If there is an equilibrium with specialization, both intermediate goods need be produced and

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so union firms must be indifferent between producing both. So $\pi_1^u = \pi_2^u$. We also have $p_1 + p_2 = (1 - \tau) p_f$. Using these two equations, we can solve out for p_1 as

$$p_1 = \frac{(c_2^u)^{-\gamma}}{(c_1^u)^{-\gamma} + (c_2^u)^{-\gamma}} (1 - \tau) p_f. \tag{17}$$

Plugging this into (16) and using straightforward algebra, a union firm prefers specialization to integration if and only if

$$\frac{(c_2^u)^{-\gamma} (c_1^u)^{-\gamma}}{(c_1^u)^{-\gamma} + (c_2^u)^{-\gamma}} (1 - \tau) > \left(\frac{1}{2}\right)^{1-\gamma} (c_{VI}^u)^{-\gamma}. \tag{18}$$

Recall from the previous section that $c_1^u + c_2^u < c_{VI}^u$. A lemma in the appendix shows when $c_1^u + c_2^u < c_{VI}^u$ holds, (18) holds at $\tau = 0$. Define $\hat{\tau}$ to be the unique τ where (18) holds with equality. *Q.E.D.*

The key step in this result is the analysis in the previous section that shows that $c_1^u + c_2^u < c_{VI}^u$. At the union wages, the total cost of one activity unit of each good is less when the intermediate inputs are produced separately than when they are produced together in a vertically integrated firm. By splitting the businesses up, producers have better bargaining power with the union in aggregate. So if there is no friction, $\tau = 0$, there will be specialization in the market outcome. Of course, any transactions cost will offset these benefits. The critical value $\hat{\tau}$ is where the savings generated from better aggregate bargaining power exactly offsets the transactions cost.

Figure 1 illustrates how $\hat{\tau}$ varies with w°, fixing $\alpha_1 = .9$ and $\gamma = .5$. Now there is a U-shaped relationship with the minimum value obtained at the point where the market cost of labor w° is a little bit above one (the cost of capital). Note that for this α and γ, $\hat{\tau}$ is a relatively big number. The transaction cost can dissipate 10 percent in output and yet specialization takes place. If we change α_1 and γ the cutoff changes. If we increase α_1 above $\frac{1}{2}$, (which makes the two intermediates more different in their production structure), the cutoff increases. The parameter γ has an ambiguous impact on $\hat{\tau}$. For γ close to zero and γ close to one, it appears that $\hat{\tau}$ goes to zero. It is intuitive that as γ goes to one, the firm becomes very elastic and so wage offers by the union get close to the market offer w°. It is for intermediate levels of γ that $\hat{\tau}$ is large.

Next we allow for the possibility of nonunion firms. If all firms were nonunion and if there were any transactions cost $\tau > 0$, then all firms would be vertically integrated. This

follows because specialization has a cost but no benefits. But what if there are both union and nonunion firms? The first question is: Will the nonunion firms want to trade with the union firms and specialize in one of the two intermediates? The second question is: If there is trade and nonunion firms specialize in an intermediate input, which intermediate do they choose? Propositions 2 and 3 address these questions.

Proposition 2. Assume $\tau > 0$. In any equilibrium where any nonunion firm specializes, the nonunion firm produces intermediate good 1 (the labor intensive good).

Proof. We prove this here for the special case where $w^\circ = 1$ and treat the general case in the appendix. Now if $w^\circ = 1$, for the nonunion firm the cost of one activity unit is the same for each intermediate. (Since the two intermediates are symmetric and since the cost of capital is one).In the appendix we show that for the union firm $c_1^u > c_2^u$. While a specialist union producer of intermediate 1 faces a lower wage than a specialist producer of 2, $w_1^u < w_2^u$, the producers of 1 have a higher labor share than the producers of 2 and the net effect is positive on the total cost of the activity.

It cannot be that there are nonunion producers of both specialist goods. If so, we can cut back production by nonunion producers of both types of specialist goods and have these vertically integrate. This saves transactions cost with no change in production costs which is inconsistent with profit maximization.

We consider two cases. Suppose first that union firms weakly prefer being a specialist in intermediate 1 over intermediate 2. Since $c_1^u > c_2^u$, it must be that $p_1 > p_2$, otherwise, union firms would strictly prefer intermediate 2. But since $c_1^n = c_2^n$ (because $w^\circ = 1 = r$), $p_1 > p_2$ implies nonunion firms strictly prefer to produce intermediate 1, as claimed.

The second case is where in equilibrium, union firms strictly prefer being a specialist in intermediate 2. There has to be someone on the other side of this market, so nonunion firms must be producing intermediate 1. *Q.E.D.*

Proposition 3. There exists a $\tilde{\tau} > 0$, so that if $\tau < \tilde{\tau}$, there exist nonunion firms specializing in the labor intensive task. If $\tau > \tilde{\tau}$, all nonunion firms are vertically integrated. For $\tau < \tilde{\tau}$, there exists a $\tilde{\phi}(\tau)$ such that if the nonunion share satisfies $\phi < \tilde{\phi}(\tau)$, then all nonunion firms specialize in intermediate 1. If $\phi > \tilde{\phi}(\tau)$ (but $\phi < 1$), a positive measure of nonunion firms specialize in intermediate 1 and a positive measure are vertically integrated and nonunion firms are indifferent between these two alternatives. In this case all union firms specialize in intermediate 2 (the capital intensive task).

Sketch of Proof. As in Proposition 2, we treat the case of $w^\circ = 1$ and defer the general case to the appendix. Now if $\tau = 0$, equilibrium condition (4) reduces to $p_1 + p_2 = p_f$. In

the proof of Proposition 2, we show that $p_1 > p_2$, so $p_1 > \frac{1}{2}p_f$. For the nonunion firms, it is immediate that $w° = 1$ implies $c_1 = \frac{1}{2}c_{VI}$. So specializing and producing q units of intermediate 1 has the same cost of producing $\frac{1}{2}q$ units of the final good but the revenues are strictly greater. Hence at $\tau = 0$, nonunion firms strictly prefer to specialize in intermediate 1. This proves only that for small τ, the result holds. The more general result is proved in the appendix. *Q.E.D.*

We note that the cutoff $\tilde{\tau}$ determining whether or not nonunion firms want to trade with union firms may be above or below the cutoff $\hat{\tau}$ determining vertical structure when all firms are union. Suppose that $\hat{\tau} < \tilde{\tau}$. Then if $\tau < \tilde{\tau}$, any nonunion firm will specialize in intermediate 1, to the extent that there are enough union firm specializing in intermediate 2 to trade with. If $\tau < \hat{\tau} < \tilde{\tau}$, then some union firms may specialize in intermediate 1 as well, if there are not enough nonunion firms to do this job.

Suppose next that $\tilde{\tau} < \hat{\tau}$. If $\tau \in (\tilde{\tau}, \hat{\tau})$, then nonunion firms will not trade with union firms in equilibrium. Rather the nonunion firms will be vertically integrated while union firms will specialize in the two different tasks. If instead $\tau < \tilde{\tau} < \hat{\tau}$, then nonunion firms will trade with union firms by specializing in intermediate 1.

5   Endogenous Wages and Multiple Equilibria

So far we have taken wages as exogenous. In this section we allow wages to be endogenous. For simplicity we continue to assume the price of capital is exogenous at $r = 1$ (we intend to allow for the price of capital to be endogenous in a future draft.) Finally, we simplify by assuming all firms are union ($\phi = 0$).

There is a fixed stock $\bar{L}$ of labor in the economy. This labor can be allocated between seeking monopoly rents and working in the competitive labor market. Let L^R be the amount of labor allocated to rent seeking and let $L°$ be the amount allocated to the competitive labor market. The idea of introducing rent seeking as a use of labor is that it will connect the existence of unions rents to the competitive labor market.

Assume that the union monopoly rents are split equally among the measure L^R of workers who seek them. It might be easier to interpret this if we allow the acquisition of the monopoly rents to be a random of event and assume the workers are risk neutral. The important thing is that the rents are divided equally among the rent seekers in expectation.

Let R^u be the total value of union rents across all union firms. In equilibrium, workers

must be indifferent between rent seeking and working in the competitive labor market, i.e.,

$$\frac{R^u}{L^R} = w^\circ.$$

Also we need to have the demand for labor in the competitive labor market across all firms (including union firms who ultimately employ workers from this market) to equal the supply L°. We need $\bar{L} = L^R + L^\circ$. Finally, we need all of the earlier equilibrium conditions to hold as well.

Of particular interest in this section is the possibility of multiple equilibria. To get a hint of this possibility, examine Figure 1. We see that for τ above the minimum level on the curve, as we vary w° (taken as exogenous earlier in the paper) we have three cases. For low w, we are below the curve meaning specialization occurs in equilibrium. For moderate w we are above the curve so vertical integration occurs in equilibrium. For high w we are back below the curve so again specialization.

Unions do worse on average when firms are specialized. In the setup of this section, the loss of union rents gets transferred over to the competitive labor market. Rent seeking becomes less attractive so fewer workers are absorbed from this market driving down w°. This discussion suggests the possibility that for the same model parameters, they can be a low wage equilibrium where firms are specialized and a high wage equilibrium where firms are vertically integrated.

It is easy to construct examples with this feature. We continue to use the parameters used to construct Figure 1, where $\alpha = .9$ and $\gamma = .5$. We set $\tau = .096$. It is not possible to see this in the Figure 1, but at $w^\circ = 1$, $\hat{\tau} = .0946$. So at this w° and $\tau = .096$, we are above the $\hat{\tau}$ cutoff and vertical integration would be the equilibrium. In Table 1 we illustrate a level of $\bar{L}$ that would result in vertical integration equilibrium with $w^\circ = 1$. This requires $\bar{L} = 2.17$. If this is the total labor, an amount .70 of labor enters the competitive labor market and the rest goes into rent seeking.

Now at this τ, if w° were to be below .935, firms would specialize. We can construct a second equilibrium with the same total labor supply of $\bar{L} = 2.17$ in which the equilibrium open market wage is $w^\circ = .85$. With this lower wage, firms want to vertically disintegrate. With a lower wage and vertical disintegration rather than integration, monopoly rents decrease. So there are less rents to seek which contributes to driving down the open market wage. In this second equilibrium with specialization, workers are worse off. Profits are higher. The amount of final good is higher, despite the fact that specialization incurs a

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transaction friction that is not incurred in the vertical integration equilibrium.

6 Understanding Changes over Time in Vertical Structure

We use the model to discuss changes over time in vertical structure.

The first driving force we discuss is changes in the transactions cost τ. Decreases in transportation cost and in communication costs can very well have led to a reduction in τ over time. Antras, Garicano, and Rossi-Hansberg (2006) emphasize decreases of such costs at the international level. Presumably, these kinds of transactions costs have fallen for within country exchange as well. In the model, assume all firms are union, ($\phi = 0$). From Figure 1 we see that if transactions cost are initially high enough, there will be vertical integration. If transactions continually fall over time and eventually get small, there will be specialization in the long run. Note that firms are ex ante homogenous in the model (with $\phi = 0$) so this equilibrium specialization in the long run is not based on traditional comparative advantage.

Next consider changes in the fraction ϕ that are unionized. Let ϕ_t denote the dependence of this fraction on time. The fraction union could potentially be endogenized but we abstract from this here. The fraction union depends very much on the legal environment as well and that is the focus here. Freeman (1998) discusses the importance of the legal environment and Figure 2 is from his paper. Basically, in the 1930s, favorable laws were passed (in particular the National Labor Relations Act (The Wagner Act) resulting in a spurt of unionism. The unionization rate of the nonagricultural labor force peaked at 35 percent in the 1940s and if we focus more narrowly on heavy manufacturing such as auto and steel the vast majority of the industry was organized at this time. Subsequent to the 1930s the pendulum regarding legal support for unions has swung the other way, beginning with the Taft-Hartley act in 1947. Unionized firms have exited and have been replaced by nonunion firms that are more difficult to organize than firms were in the 1930s. We capture this sequence of events in the following stylized way. Assume that at time 0, $\phi_0 = 1$, so all firms are nonunion. then at time $t = 1$ legislation leads to unionization of all firms,so $\phi_1 = 0$. Subsequently, union firms gradually die out and are replaced by nonunion firms who stay nonunion. So ϕ_t increases over time and $\lim_{t \to \infty} \phi_t = 1$.

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A particularly interesting case is where $\tilde{\tau} < \hat{\tau}$ and where $\tau \in (\tilde{\tau}, \hat{\tau})$. At time 0 (e.g. the 1920s) all firms are nonunion and so are vertically integrated. This is the glory time for the Ford's River Rouge plant. At time $t = 1$ (e.g. the 1930s) all firms are nonunion. Since $\tau > \hat{\tau}$ for this case, firms remain vertically integrated. Now over time as union firms gradually die out and are replaced by nonunion firms, since $\tau < \tilde{\tau}$, the nonunion firms specialize in the labor intensive task while the union firms begin to vertically disintegrate. So specialization or outsourcing increases in the early periods. Eventually, as all the union firms die out, specialization decreases, as nonunion firms have no need to trade with each other. So we see that in this model an increase in nonunion firms starting from zero can contribute to specialization. But if unions are wiped out completely then we return to vertical integration.

The last thing we consider are changes in the equilibrium that are internal to the model and not from exogenous changes in underlying parameters. We refer here to the multiple equilibria in the previous section. In the example of Table 1, we can think of the vertical integration equilibrium as corresponding to the 1950s and that era. The specialization equilibrium corresponds to the present. We don't have a story of how one might move from one to the other (thought perhaps changes in things like τ or ϕ might help tip things). The key point illustrated here is positive feedback. If some firms switch to vertical disintegration, this tends to break rents collected by workers, which in turn depresses the open market wage. This makes it more desirable for other firms to be specialized. This positive feedback is reminiscent to the positive feedback in McLaren (2000) though the mechanism is quite different.

Appendix

7   Notes for Union Wages and Costs

7.1   Analysis of The Vertical Integrated Firm's Labor Demand

For the integrated firm,

$$
\begin{aligned}
c_{VI}(w, y) &= w^{\alpha_1}y + w^{\alpha_2}y = (w^{\alpha_1} + w^{\alpha_2})\,y \\
&= c_{VI}\,y
\end{aligned}
$$

Now if the firm produces y of each input, it gets in final good

$$
\begin{aligned}
q_f &= y\,(2y)^{-(1-\gamma)} && (19) \\
&= 2^{-(1-\gamma)}y^{\gamma}. && (20)
\end{aligned}
$$

So the problem is

$$
\max p_f 2^{-(1-\gamma)}y^{\gamma} - c_{VI}y
$$

The FONC is

$$
p_f 2^{-(1-\gamma)}\gamma y^{\gamma-1} - c_{VI} = 0
$$

Or

$$
y = \left(p_f 2^{-(1-\gamma)}\gamma\right)^{\frac{1}{1-\gamma}} c_{VI}^{-\frac{1}{1-\gamma}}
$$

We can plug this into labor demand:

$$
\begin{aligned}
l &= \alpha_1 w^{-(1-\alpha_1)}y + \alpha_2 w^{-(1-\alpha_2)}y \\
&= \left(\alpha_1 w^{-(1-\alpha_1)} + \alpha_2 w^{-(1-\alpha_2)}\right)\left(p_f 2^{-(1-\gamma)}\gamma\right)^{\frac{1}{1-\gamma}} c_{VI}^{-\frac{1}{1-\gamma}} \\
&= \left(p_f 2^{-(1-\gamma)}\gamma\right)^{\frac{1}{1-\gamma}}\left(\alpha_1 w^{-(1-\alpha_1)} + \alpha_2 w^{-(1-\alpha_2)}\right)\left(w^{\alpha_1} + w^{\alpha_2}\right)^{-\frac{1}{1-\gamma}} \\
&= \xi\left(\alpha_1 w^{-(1-\alpha_1)} + \alpha_2 w^{-(1-\alpha_2)}\right)\left(w^{\alpha_1} + w^{\alpha_2}\right)^{-\frac{1}{1-\gamma}}
\end{aligned}
$$

7.2 The Union Problem facing a Vertically Integrated Firm

Using the results of the previous section, a labor union facing a vertically integrated firm sets w to maximize:

$$(w - w^\circ)\xi \left(\alpha_1 w^{-(1-\alpha_1)} + \alpha_2 w^{-(1-\alpha_2)}\right)\left(w^{\alpha_1} + w^{\alpha_2}\right)^{-\frac{1}{1-\gamma}}$$

To simplify the notation, let $\alpha_1 = \alpha$ and $\alpha_2 = 1 - \alpha$. Then ignore the multiplicative scaler ξ and look at

$$\max(w - w^\circ)\left(\alpha w^{-(1-\alpha)} + (1-\alpha)w^{-\alpha}\right)\left(w^\alpha + w^{(1-\alpha)}\right)^{-\frac{1}{1-\gamma}}$$

The FONC is

$$
\begin{aligned}
0 = \ & \left(\alpha w^{-(1-\alpha)} + (1-\alpha)w^{-\alpha}\right)\left(w^\alpha + w^{(1-\alpha)}\right)^{-\frac{1}{1-\gamma}} \\
& - \alpha(1-\alpha)(w - w^\circ)(w^{\alpha-2} + w^{-\alpha-1})\left(w^\alpha + w^{(1-\alpha)}\right)^{-\frac{1}{1-\gamma}} \\
& - \left(\frac{1}{1-\gamma}\right)(w - w^\circ)\left(\alpha w^{-(1-\alpha)} + (1-\alpha)w^{-\alpha}\right)\left(w^\alpha + w^{(1-\alpha)}\right)^{-\frac{1}{1-\gamma}-1}\left(\alpha w^{\alpha-1} + (1-\alpha)w^{-\alpha}\right)
\end{aligned}
$$

Can simplify a bit, by dividing through by $\left(w^\alpha + w^{(1-\alpha)}\right)^{-\frac{1}{1-\gamma}}\left(\alpha w^{-(1-\alpha)} + (1-\alpha)w^{-\alpha}\right)$. In this this case get

$$
\begin{aligned}
0 = \ & 1 \\
& - \alpha(1-\alpha)(w - w^\circ)\frac{\left(w^{-(1-\alpha)} + w^{-\alpha}\right)}{\left(\alpha w^\alpha + (1-\alpha)w^{1-\alpha}\right)} \\
& - \left(\frac{1}{1-\gamma}\right)(w - w^\circ)\frac{\left(\alpha w^{-(1-\alpha)} + (1-\alpha)w^{-\alpha}\right)}{w^\alpha + w^{(1-\alpha)}}
\end{aligned}
$$

In the limiting case of $\alpha = 1$, then the above reduces to

$$0 = 1 - \left(\frac{1}{1-\gamma}\right)(w - w^\circ)\frac{1}{w+1}.$$

Solving for the optimal w yields

$$
\begin{aligned}
(1 - \gamma)(w + 1) &= w - w^{\circ} \\
1 - \gamma + w^{\circ} &= \gamma w \\
w_{VI}^{u} &= \frac{1 - \gamma + w^{\circ}}{\gamma}
\end{aligned}
$$

7.3 A Comparison of Costs

We prove Lemma 1 in the text, that

$$
\lim_{\alpha \to 1} [c_1^u + c_2^u] < \lim_{\alpha \to 1} c_{VI}^u
$$

Plugging in the definitions of the various c^u, this is equivalent to

$$
\lim_{\alpha \to 1} \left[w_1^\alpha + w_2^{1-\alpha} \right] < \lim_{\alpha \to 1} \left[w_{VI}^\alpha + w_{VI}^{1-\alpha} \right]
$$

Now from above

$$
\begin{aligned}
&\lim_{\alpha \to 1} \left[w_{VI}^\alpha + w_{VI}^{1-\alpha} \right] \\
&= \left[\frac{1 - \gamma + w^{\circ}}{\gamma} \right] + 1
\end{aligned}
$$

Next look at specialization. Note that

$$
\varepsilon_2 \equiv \frac{1 - (1 - \alpha_2)\gamma}{1 - \gamma} = \frac{1 - \alpha\gamma}{1 - \gamma} \tag{21}
$$

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Hence:

$$\lim_{\alpha \to 1} \left[w_2^{1-\alpha} \right]$$

$$= \lim_{\alpha \to 1} \left[\frac{1}{1 - \frac{1}{\varepsilon}} w^\circ \right]^{1-\alpha}$$

$$= \lim_{\alpha \to 1} \left[\frac{1}{1 - \frac{1-\gamma}{1-\alpha\gamma}} w^\circ \right]^{1-\alpha}$$

$$= \lim_{\alpha \to 1} \left[\frac{1 - \alpha\gamma}{\gamma(1 - \alpha)} w^\circ \right]^{1-\alpha}$$

$$= \lim_{\alpha \to 1} \left[\frac{1 - \alpha\gamma}{(1 - \alpha)} \right]^{1-\alpha} \lim \left(\frac{1}{\gamma} \right)^{1-\alpha} \lim w^{\circ 1-\alpha}$$

$$= \lim_{\alpha \to 1} \left[\frac{1 - \alpha\gamma}{(1 - \alpha)} \right]^{1-\alpha}$$

$$= 1$$

The last equality is proved in separate notes. This proves that

$$\lim_{\alpha \to 1} w_2^{1-\alpha} = 1 = \lim_{\alpha \to 1} w_{VI}^{1-\alpha}.$$

So it is sufficient to show that

$$\lim_{\alpha \to 1} \left[w_1^\alpha \right] < \lim_{\alpha \to 1} \left[w_{VI}^\alpha \right].$$

But this is immediate since $w_1 < w_{VI}$.

8   Notes for Equilibrium Vertical Structure

The proof of Proposition 1 appealed to the following lemma:

Lemma 2. Suppose for $x > 0$, $y > 0$ there is a $z \geq x + y$. Then

$$\frac{x^{-\gamma} y^{-\gamma}}{x^{-\gamma} + y^{-\gamma}} > \left(\frac{1}{2} \right)^{1-\gamma} z^{-\gamma}$$

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Proof. We can rescale so that $x + y = 1$ and show results holds for $z = 1$ or

$$\frac{x^{-\gamma}(1-x)^{-\gamma}}{x^{-\gamma}+(1-x)^{-\gamma}} > \left(\frac{1}{2}\right)^{1-\gamma} \tag{22}$$

Define $H(x)$ by

$$H(x) \equiv 2x^{-\gamma}(1-x)^{-\gamma} - 2^{\gamma}x^{-\gamma} - 2^{\gamma}(1-x)^{-\gamma}$$

Straightforward manipulation of (22) shows that it holds if $H(x) > 0$ for $x \in [0, \frac{1}{2})$. Now it is easy to verify that $H(\frac{1}{2}) = 0$. So it is sufficient to show that $H'(x) < 0$ for $x \in [0, \frac{1}{2})$. Now

$$\begin{aligned}
H'(x) &= -\gamma 2 x^{-\gamma-1}(1-x)^{-\gamma} + \gamma 2 x^{-\gamma}(1-x)^{-\gamma-1} \\
&\quad -\gamma 2^{\gamma} x^{-\gamma-1} + \gamma 2^{\gamma}(1-x)^{-\gamma-1}
\end{aligned}$$

This is negative if and only if

$$2x^{-\gamma-1}(1-x)^{-\gamma} + 2^{\gamma}x^{-\gamma-1} > 2x^{-\gamma}(1-x)^{-\gamma-1} + 2^{\gamma}(1-x)^{-\gamma-1}$$

or

$$2(1-x) + 2^{\gamma}(1-x)^{\gamma+1} > 2x + 2^{\gamma}x^{\gamma+1}$$

Which is true because $x < \frac{1}{2}$. Q.E.D.

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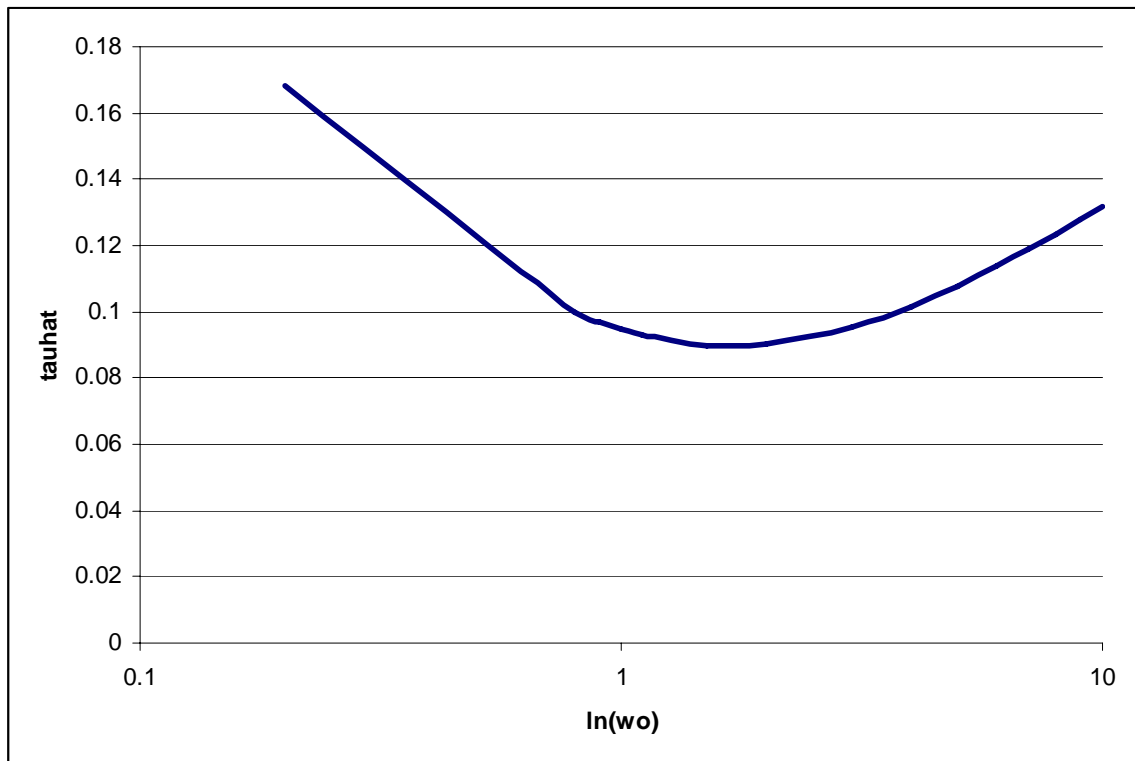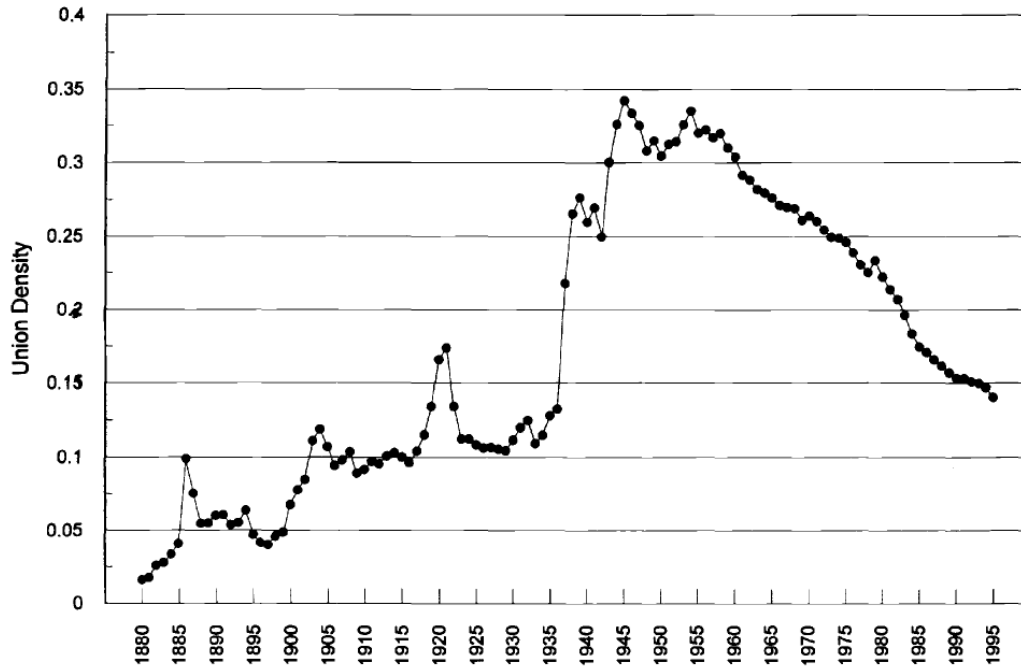
Figure 1

Figure 2: Changing Percentage of Non-Agricultural Workers Who Are Members of Unions, 1880-1995

Source: Freeman (1998), Figure 1

Table 1
Example with Multiple Equilibria
Parameters: $\alpha = .9$, $\gamma = .5$, Lbar=2.17, $\tau = .096$, $p_f = 10$

Variable	Vertical Integration Equilibrium	Specialization Equilibrium
w^0	1.00	.85
L^0	.70	.95
L^R	1.47	1.21
Lbar	2.17	2.17
p_1	-	4.86
p_2	-	4.18
profit	3.21	3.48
Total Output of Final Good	.64	.77