ON THE NEUTRALITY OF ASSET OWNERSHIP
FOR WORK INCENTIVES

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Abstract. Two ownership systems are compared: one where outsiders own the physical assets of firms and another where these assets are jointly owned by workers. Effort and side payments are self-enforced. Market-wide incentive constraints lead to restrictions on the distribution of profit between capital and labor which differ for the two systems. But these asymmetries are exactly offset by the bundling of input returns in a joint ownership economy, so for any self-enforcing equilibrium on the second-best frontier of one system there exists an equivalent equilibrium on the frontier of the other. An efficient outside ownership economy cannot be destabilized by spontaneous transitions to joint ownership or conversely. When capital is scarce, welfare maximization requires that all profit go to workers, but when labor is scarce all profit should go to asset owners.

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1. **Introduction**

There are strong economic reasons why individual workers should own their own tools. This guarantees that workers will pay attention to maintenance, and avoids costly monitoring or bargaining with an outsider who has no direct role in production. Precisely because it is so easy to see why a carpenter would own a hammer or a farmer would own a tractor, it is puzzling why large physical assets such as factories are not jointly owned by the production teams who use them. This is especially true when proper maintenance is hard for outsiders to observe, or using the asset requires highly specialized skills.

One popular approach in resolving this puzzle is to identify incentive benefits that could arise from outside ownership. For instance, Alchian and Demsetz (1972) argued that in the absence of a central owner with strong incentives to monitor asset use, workers might free ride on collective assets by depreciating them excessively. Holmstrom (1982) has suggested that apart from monitoring or depreciation issues, an outside owner could provide effort incentives for workers by functioning as a residual output claimant. This allows the use of forcing contracts where large group penalties are imposed on employees when team output is too low. Holmstrom and Milgrom (1991, 1994) show that outside ownership can be attractive when it is desirable to give workers low-powered incentives.

Here I explore the interactions between asset ownership and work incentives in a repeated game framework where effort supply and side payments are both self-enforced. Incentives are ultimately provided by the threat that employment relationships will end through quitting or firing. The model allows flexible transfers in each period before and after production, as well as transfers at the start of each new employment relationship. It also incorporates match-specific investments in physical assets and skills.

Two systems are compared: outside ownership, where physical assets are owned by someone external to the production team, and joint ownership, where assets are owned by the workforce. In each case I derive the second-best payoff frontier characterizing the effort levels and distributions of profit that can be supported by self-enforcing equilibria. These frontiers differ across ownership regimes and depend on the market environment.
If capital is scarce relative to labor in the sense that firms can fill vacancies more quickly on average than unemployed workers can find jobs, there is a lower bound on the profit stream going to labor due to a market-wide incentive constraint. This lower bound could be positive so that newly matched workers appropriate a rent although they are not scarce. In an environment of this kind, an economy where firms are jointly owned has a more relaxed constraint on profit distribution than one where firms have outside owners. For any given effort level it is therefore possible to pay lower returns to labor and higher returns to capital by having firms switch from outside to joint ownership. On the other hand, if labor is scarce relative to capital there is a lower bound on the return to capital. This lower bound may again be positive so asset owners get a rent even though assets are not scarce. In this case a transition from joint to outside ownership would permit lower returns to capital and higher returns to labor for given effort inputs.

Despite these apparent asymmetries, at a deeper level the two ownership systems are equivalent. Corresponding to every point on the second-best frontier for an outside ownership economy there is a unique point on the frontier of a joint ownership economy which gives all agents identical present values, and conversely. This isomorphism arises because asymmetries in profit distribution are exactly compensated by differences in the bundling of factor payments. Since these two effects cancel out, each individual's present value remains unchanged in a suitably designed transition from one system to the other.

The neutrality result has direct implications for the stability of ownership regimes. An outside ownership economy that is second-best efficient cannot be destabilized by Pareto-improving conversions to joint ownership, or vice versa. However, any mix of organizational forms is weakly stable, and this mix is subject to drift over time due to the feasibility of conversions that leave agents indifferent. The Kaldor-Hicks criterion shows that if capital is scarce, total welfare is maximized by having workers receive all profit in each firm, while if labor is scarce all profit should go to asset owners. Either of these two distributional outcomes can be implemented regardless of the ownership regime.

These conclusions run counter to various ideas about the role of ownership as an incentive device. To take one influential example, Holmstrom (1982) remarks: "the fact that capitalistic firms feature separation of ownership and labor implies that the free-rider problem is less pronounced in such firms than in closed organizations like partnerships."
This view has been criticized for neglecting moral hazard on the part of the owner, who might cheat employees (Eswaran and Kotwal, 1984; Andolfatto and Nosal, 1997). Here I show that Holmstrom's results depend critically on the binding commitment of the owner to condition wages on output. If payments to employees must instead be self-enforced, outside ownership does no better than joint ownership in resolving free-rider dilemmas.

More generally, the neutrality results obtained here highlight the dangers in trying to study the property rights structure of a single firm in isolation. Self-enforcement leads to fundamental incentive externalities across firms: a worker's incentive to supply effort today depends on the expected division of profit in future relationships, which determines the payoff from quitting or firing. The same is true for an owner's incentive to provide promised wages or bonuses. Thus it is necessary to solve for a self-enforcing equilibrium in the labor market as a whole, and the efficiency of resource allocation cannot be cleanly separated from distributional concerns.

There is a close kinship between the theory developed here and previous repeated game models of effort supply (Cremer, 1986; Bull, 1987; Putterman and Skillman, 1992; Dow and Dong, 1993). The focus on dismissal threats as a source of effort incentives is also in the spirit of efficiency wage models (Shapiro and Stiglitz, 1984; Bowles, 1985). The closest previous research is by MacLeod and Malcomson (1989, 1993, 1998) on self-enforcing labor market equilibria. These authors adopt a repeated game framework and derive market-wide incentive constraints like those in section 3. However, MacLeod and Malcomson treat outside ownership as given and emphasize the contrast between bonuses and efficiency wages, rather than the issues surrounding property rights in firms.

Section 2 presents the modeling framework used throughout the paper. Incentive constraints for economies with outside and joint ownership are derived in sections 3 and 4 respectively. Section 5 establishes the neutrality of ownership and develops stability and welfare results. Section 6 discusses broader implications for the theory of the firm.

2. The Model

I consider a labor market with many identical firms and many identical workers. Production requires an indestructible asset and a team of \( n \) \((\geq 2)\) workers. The production function is \( q(e_1, e_2, \ldots, e_n) \) where \( e_i \geq 0 \) is the effort input of worker \( i \). This function is
symmetric, concave, increasing when all inputs are positive, and twice continuously differentiable. Inputs are essential ($e_i = 0$ for any $i$ gives $q = 0$) and complementary (cross partials are non-negative). Effort has a cost $c(e_i)$ with $c(0) = c'(0) = 0$, $c(e_i) > 0$ and $c'(e_i) > 0$ for $e_i > 0$, and $c''(e_i) > 0$ for $e_i \geq 0$. Output is sold at a competitive price $p > 0$. Profit is $\pi = pq(e_1 \ldots e_n) - \sum_i c(e_i)$, which for any $p > 0$ has a finite maximum. All agents are risk neutral and infinitely-lived, with the common per-period discount factor $\delta \in (0,1)$. Workers can get a payoff of zero in any period from home production while owners of physical assets can get zero in any period by shutting down.

For outside ownership, events in each period unfold as follows. The first three steps in the sequence apply only to firms where one or more jobs are vacant at the start of a period. The remaining steps apply to all firms.

**Search.** Unmatched agents search for partners. A firm having one or more job vacancies either fills all its vacancies or none: the probability of filling vacancies is $\beta_K \in (0,1]$. The probability that an unemployed worker gets a job is $\beta_L \in (0,1]$. 

**Investment.** Owners of assets may need to alter them before use by new workers, and new workers may need to acquire firm-specific skills before producing. The costs of these specialized investments per new worker are denoted by $g_K \geq 0$ and $g_L \geq 0$.

**Fees.** After investment there are simultaneous side payments from the asset owner to each new worker ($m_K \geq 0$), and from newly hired workers to the asset owner ($m_L \geq 0$).

**Wages.** In all firms side payments can be made prior to production. A wage payment from the asset owner to a worker is denoted by $w_K \geq 0$. A simultaneous rental payment from a worker to the owner for use of the physical asset is denoted by $w_L \geq 0$.

**Effort.** Workers in each firm simultaneously choose effort levels, and output is produced according to the production function $q(e_1 \ldots e_n)$.

** Appropriation.** After output is produced the revenue $pq$ is divided. Each worker receives the fraction $s \in [0,1/n]$ of $pq$, with the residual share $1 - ns$ going to the asset owner.
**Bonuses.** After output is produced and appropriated, simultaneous side payments are again possible. A post-production transfer from an owner to a worker is denoted by $b_K \geq 0$. A transfer from a worker to an owner is denoted by $b_L \geq 0$.

**Renewal.** At the end of a period the owner decides whether to fire some or all workers, and workers simultaneously decide whether to continue or quit. With probability $1-\alpha \in (0,1)$ nature dissolves the team even if the owner and all workers want to continue.

Because no output can be produced unless all jobs are occupied, it is simplest to assume that firms either fill all of their vacancies or none of them. Workers who do not find jobs get zero payoffs for the current period and can search again in the next period. Likewise if some job is not filled the asset owner can return to the market next period.

The firm-specific expenditures $(g_K, g_L)$ needed to make a new worker productive are borne by the owner and worker respectively. Investments are binary so the required expenditure is either made or not. Each party can refrain from investment after being matched, which is equivalent to a vacancy remaining unfilled: no output is produced and the owner and worker search again next period. The costs of specialized investments can be shifted from one party to another at the fee stage. More generally, fees determine how the total profit stream from a match is divided ex ante.

The remaining stages apply to all firms, whether new matches took place or not. Wage or rental payments can be used to reassign the profit flow from an ongoing match, while bonuses enable owners to condition current-period worker compensation on effort. It is also necessary to say how firm revenue is divided, which occurs at the appropriation stage. I treat the share parameter as an exogenous element in the ownership system of the firm and examine its comparative static effects in section 3. Additional opportunities for side payments would not alter any conclusions in the paper.

The renewal stage reflects the fact that continuation of employment relationships is voluntary. Nature may also dissolve a production team for exogenous reasons, perhaps because the firm must relocate. I abstract from turnover that is idiosyncratic to individual agents, which complicates the analysis without adding further insight.
The informational assumption used throughout the paper is that agents observe all events occurring in their own firms but nothing that occurs in other firms. Specifically, asset owners and incumbent workers see new matches, investments, fees, wages, effort, bonuses, and renewal decisions. Unemployed workers do not see any of these actions. At the investment stage newly matched workers are uninformed about the total number of vacancies filled in the current period, and at the fee stage only know whether investments were made for their own job. After the fee stage they learn how many jobs were filled in the current period, discover what investments were made for the other jobs, and observe all further actions in the firm. If there is no quitting or firing in equilibrium, Bayesian reasoning requires newcomers to believe that vacancies arose by exogenous dissolution in an earlier period, or reflect a lack of success in filling jobs since the firm was founded. New workers do not infer from the mere existence of a vacancy that an earlier deviation triggered dismissal or quitting, and thus continue along the equilibrium path when hired.

Agents use non-cooperative strategies to choose actions in each successive match. When firms have outside owners, the strategies of owners and workers are denoted by $\sigma_K$ and $\sigma_L$. For an asset owner $\sigma_K$ specifies, after any history, whether to search if vacancies exist; whether to invest ($g_K \geq 0$) if a vacancy is filled; what fee ($m_K \geq 0$) to pay each new worker; what wage ($w_K \geq 0$) to pay each worker before production; what bonus ($b_K \geq 0$) to pay each worker after production; and whether to fire each worker at the renewal stage. For a worker $\sigma_L$ specifies, after any history, whether to search for a job if unemployed; whether to invest ($g_L \geq 0$) if matched; what fee ($m_L \geq 0$) to pay the owner; what rental ($w_L \geq 0$) to pay before production; what effort level ($e \geq 0$) to choose; what bonus ($b_L \geq 0$) to pay the owner after production; and whether to quit at the renewal stage.

Identical agents are assumed to adopt identical strategies in equilibrium, and asset owners treat all workers symmetrically. I confine attention to stationary equilibria where actions are identical in every period along the equilibrium path.

3. Market Equilibria with Outside Ownership

When firms have outside owners, a stationary and symmetric market equilibrium can be summarized by $(m_K, m_L; w_K, w_L; e; b_K, b_L)$ where $e$ is effort and the other variables are non-negative side payments. In a non-trivial equilibrium unattached agents must be
willing to search and invest. All equilibria discussed below have this property. There are two kinds of stationary equilibria: those where matches end by quitting and/or firing after one period, and those where matches are renewed until dissolved by nature. One-period equilibria make it possible to punish deviations from equilibria involving renewal, but only support one-shot Nash effort levels. Since the same effort levels can be supported when matches are renewed, I focus on equilibria with renewal.2

Suppose \((\sigma_K, \sigma_L)\) is a stationary, symmetric, subgame perfect strategy pair where search, investment, and renewal occur. Let \(V_K\) be the owner's equilibrium present value per job after the fee stage when all jobs are filled, with \(V_L\) as the corresponding present value for a worker. Let \(U_K\) be the equilibrium present value per job the owner obtains by search in a period where all jobs are vacant, with \(U_L\) as the present value an unemployed worker obtains by search. Define \(m \equiv m_L - m_K\) to be the net fee paid by each new worker, \(w \equiv w_K - w_L\) to be the net wage paid by the asset owner to each worker, and \(b \equiv b_K - b_L\) to be the net bonus paid by the owner to each worker on the equilibrium path. Let \(q(e)\) be output when all workers choose the same effort level \(e\). Stationarity implies

\[
V_K = -w + (1/n - s)pq(e) - b + \delta[\alpha V_K + (1-\alpha)U_K] \tag{1a}
\]
\[
V_L = w + spq(e) - c(e) + b + \delta[\alpha V_L + (1-\alpha)U_L] \tag{1b}
\]

The present value per job derived from search by an owner who has \(n\) vacancies is \(U_K = \beta K(V_K + m - g_K)[1+ \delta(1-\beta K) + \delta^2(1-\beta K)^2 + \ldots]\), and similarly for \(U_L\). This gives

\[
U_K = \beta K(V_K + m - g_K)/[1-\delta(1-\beta K)] \tag{2a}
\]
\[
U_L = \beta L(V_L - m - g_L)/[1-\delta(1-\beta L)] \tag{2b}
\]

It will often be convenient to use the following change of variables. Define

\[
z_K \equiv -w + (1/n - s)pq(e) - b + (1-\alpha\delta)(m - g_K) \tag{3a}
\]
\[
z_L \equiv w + spq(e) - c(e) + b - (1-\alpha\delta)(m + g_L) \tag{3b}
\]
These are the per-job profit flows for the owner and a worker, adjusted to express fees and investments as per-period averages over the life of the relationship. The total profit stream available for distribution between an owner and worker is

\[ z(e) = z_K + z_L = \frac{pq(e)}{n} - c(e) - (1-\alpha\delta)G \]  

(4)

where \( G = g_K + g_L \) is the total expenditure on match-specific investments.

Solving the earlier equations for \( V_K, V_L, U_K, U_L \) and substituting \( z_K \) and \( z_L \) yields

\[ U_K = \beta_K z_K / (1-\delta)[1-\alpha\delta(1-\beta_K)] \geq 0 \]  

(5a)

\[ U_L = \beta_L z_L / (1-\delta)[1-\alpha\delta(1-\beta_L)] \geq 0 \]  

(5b)

where the inequalities follow from the fact that owners and workers are willing to search. The profit distribution \((z_K,z_L)\) thus uniquely determines the present values \((U_K,U_L)\) from participation in the labor market. It can also be shown that

\[ V_K - U_K = (1-\beta_K)z_K / [1-\alpha\delta(1-\beta_K)] - m + g_K \geq 0 \]  

(6a)

\[ V_L - U_L = (1-\beta_L)z_L / [1-\alpha\delta(1-\beta_L)] + m + g_L \geq 0 \]  

(6b)

where the inequalities follow from the fact that along the equilibrium path input suppliers are willing to renew their relationships at the end of each period.

Let \( q(e',e) \) be output when one worker chooses \( e' \) while all other workers choose \( e \), and define \( T(e|s) = \max_{e'} \{ spq(e',e) - c(e') \} - [spq(e) - c(e)] \geq 0 \). A best reply exists by the assumptions of section 2. For notational economy let \( \theta_K = \alpha\delta(1-\beta_K)/[1-\alpha\delta(1-\beta_K)] \) and \( \theta_L = \alpha\delta(1-\beta_L)/[1-\alpha\delta(1-\beta_L)] \). I will also write \( V = V_K + V_L \) and \( U = U_K + U_L \).

**Proposition 1** (outside ownership economy). The effort \( e \geq 0 \) and profit division \((z_K,z_L) \geq 0\) with \( z_K + z_L = z(e) \) can be supported by a stationary, symmetric, and subgame perfect
strategy pair \((\sigma_K, \sigma_L)\) with search, investment, and renewal in equilibrium, starting from a history where every firm has either \(n\) vacancies or no vacancies at the search stage, if and only if \(\theta_K z_K + \theta_L z_L \geq T(e|s) - \alpha \delta G\). This is equivalent to \(\alpha \delta (V-U) \geq T(e|s)\).

**Proof.** Available from the author upon request.³

**Remark.** Let \(e^N > 0\) be the unique non-trivial Nash equilibrium effort level for the one-shot effort supply game where each worker has the residual claim \(s = 1/n\). If \(e \in [0, e^N]\) there is a share \(s \in [0, 1/n]\) such that \(T(e|s) = 0\). If \(e > e^N\) then for the given \(e\), \(T(e|s)\) is minimized at \(s = 1/n\) and this yields \(T(e|1/n) > 0\).

This remark says that when the desired effort \(e\) does not exceed \(e^N\) it is possible to support \(e\) as a one-shot equilibrium by some set of residual claims, and this eliminates any temptation for workers to shirk. Proposition 1 then implies that any distribution \((z_K, z_L) \geq 0\) of the resulting profit \(z_K + z_L = z(e)\) can be supported. On the other hand, when \(e\) exceeds \(e^N\) the temptation to shirk is minimized by giving workers the largest possible residual claim. However, some temptation remains so that Proposition 1 may impose restrictions on the distribution of \(z(e)\). Because this is the interesting case, in the rest of the paper I assume \(e > e^N\) and \(s = 1/n\), and define \(T(e) \equiv T(e|1/n)\).

The investment expenditure \(G\) plays two roles in the model. First, it appears in Proposition 1, where the incentive constraint is relaxed for higher \(G\) because preservation of existing employment relationships becomes more valuable, giving quitting and firing threats additional bite. But it is also true that higher costs reduce the joint profit from any match through equation (4). In both cases only total firm-specific investment matters, not the sunk costs \((g_K, g_L)\) separately.

Figure 1 depicts the supportable effort levels and profit distributions when capital is scarce relative to labor \((\beta_K > \beta_L)\), assuming the first best effort \(e^*\) maximizing profit \(z(e)\) is never feasible.⁴ Each line of slope -1 corresponds to a fixed effort level and hence a constant total profit \(z(e)\) available for distribution. The inequality \(\beta_K > \beta_L\) implies \(\theta_K < \theta_L\) in Proposition 1 which thus imposes a lower bound \(z_L^{\min}(e)\) on the profit stream paid to labor for a given effort \(e\), or equivalently an upper bound \(z_K^{\max}(e)\) on returns to capital.
The curve AB is the second-best payoff frontier for an outside ownership economy. All \((z_K,z_L)\) pairs on or below this curve satisfy the market incentive constraint in Proposition 1. Distributions of profit must also satisfy \((z_K,z_L) \geq 0\) due to the participation constraints \((U_K,U_L) \geq 0\) from (5). According to the remark after Proposition 1, all points along the isoprofit line \(z(e^N)\) are feasible, and points below this line are feasible for some residual claim \(s < 1/n\). The vertical intercept A exceeds the horizontal intercept B, and the frontier cannot go above the isoprofit line passing through A or below the isoprofit line passing through B. The frontier cuts across each intermediate isoprofit line just once. Backward-bending segments are not excluded as long as no isoprofit line is crossed more than once.

Figure 2 shows the situation where labor is scarce relative to capital \((\beta_K < \beta_L)\). As in Figure 1 the graph assumes the first best effort \(e^*\) is never feasible. Here Proposition 1 imposes an upper bound \(z_L^{\text{max}}(e)\) on the profit going to workers for any given effort level, or equivalently a lower bound on the profit to capital. In this case the horizontal intercept B exceeds the vertical intercept A, and the frontier cuts each intermediate isoprofit line once from below. Again, backward-bending segments cannot be ruled out.

The last case arises when capital and labor are equally abundant \((\beta_K = \beta_L)\). In this case Proposition 1 imposes no restriction on profit distribution because only the sum \(z_K + z_L = z(e)\) appears in the incentive constraint. Effort \(e\) is supportable if and only if \(\theta z(e) \geq T(e) - \alpha \delta G\). The second-best frontier is a straight line with slope \(-1\) corresponding to the maximum feasible \(z(e)\), which may coincide with the first best frontier or lie below it.

Figure 1 indicates that newly matched workers may have to receive a rent when capital is scarce and labor is abundant, since \(z_L > 0\) implies \(U_L > 0\) by (5b). This conflicts with the Walrasian idea that wages should fall if labor is in excess supply. Notice that in Figure 2 asset owners may have to get a rent, even though it is only workers who might shirk. Thus it is the market environment summarized by the search parameters \(\beta_K\) and \(\beta_L\), not the identity of potential shirkers, that places restrictions on profit distribution.5

It is worth emphasizing that workers may have to get an ex ante rent even though asset owners are explicitly allowed to charge up-front hiring fees at the start of each new employment relationship. The reason is that moral hazard is bilateral: workers can shirk and quit, but conversely owners can cheat on bonuses and fire innocent workers. Any market-wide shift in hiring fees diminishes one moral hazard problem while aggravating
the other.\textsuperscript{6} Up-front transfers affect the distribution of ex post surplus from continuation in (6) but drop out of the market-wide incentive constraint in Proposition 1.

An important special case arises when capital scarcity leads to $\beta_K = 1$ (vacancies filled immediately). If also $G = 0$ (generic inputs) and $s = 1/n$ (minimum temptation for shirking), the inequality in Proposition 1 reduces to $\Theta_{1ZL} \geq T(e)$. The temptation $T(e)$ is strictly positive if effort exceeds the one-shot level. The incentive constraint thus implies that labor must get a rent. The renewal constraint $V_K \geq U_K$ in (6a) implies that the net fee satisfies $m \leq 0$. Despite the rent going to newly matched workers, owners cannot collect hiring fees in a market equilibrium of this kind. This is consistent with the observation that capitalist firms almost never charge up-front fees as a condition of employment, even when employees receive large wage premiums and applicants queue for jobs.

4. **Market Equilibria with Joint Ownership**

Joint ownership of an asset implies that team members cannot be deprived of their ownership stakes as a punishment for shirking, because they have property rights in their jobs. Of course, incumbent team members are free to quit and can sell their ownership claims if they do so. In this section I assume all firms have joint asset ownership, and compare this system with the outside ownership economy in section 3.

Capital and labor supply are bundled under joint ownership, so no one can buy a claim on a firm without also becoming a labor supplier. When an unemployed worker is matched to a vacant job, she must first decide whether to invest $G = g_K + g_L$. By contrast with section 3, here it is the new worker who invests $g_K$ because there is no outside owner and the previous incumbent has departed. At the fee stage the newcomer can transmit a voluntary transfer $m - g_K \geq 0$ to her predecessor. A newly matched worker does not obtain property rights in a firm until after this fee is paid. I assume the worker's predecessor can block access to the firm, but is indifferent toward doing so and makes the job available as long as the equilibrium side payment is forthcoming. The effort and renewal stages are as before, except that team members cannot be fired. After a worker leaves by quitting or exogenous dissolution, the resulting vacancy is filled in the next period with probability $\beta_K$, and on the equilibrium path this leads to a payment $m - g_K$ from the worker's successor. All informational assumptions are identical to those in sections 2 and 3.
Because joint owners are symmetric there is no need to consider side payments at the wage or bonus stages. Such transfers create unnecessary temptations for cheating and cancel out ex ante from a distributional standpoint. Therefore in what follows only the search, investment, fee, effort, and renewal stages are relevant. At the appropriation stage \( s = 1/n \) since no outsider has a claim on firm revenue. Each worker uses a strategy \( \sigma \) that specifies, after any history, whether to search; whether to invest; what to pay the previous incumbent; what effort to supply; and whether to continue.

Equilibria where everyone quits after one period are uninteresting except insofar as they can be used to punish deviations from an equilibrium path involving renewal. I therefore investigate stationary, symmetric equilibria where unemployed workers search, firm-specific investments occur, and workers renew their membership positions on the equilibrium path. Let \( V \) be the equilibrium present value of membership after the fee stage but prior to production, and let \( U \) be the equilibrium present value prior to search for a worker who resigned from a firm at the end of the preceding period and retains an unsold claim on that firm. Writing \( U = U_K + U_L \), stationarity implies

\[
V = \frac{pq(e)}{n} - c(e) + \delta[\alpha V + (1-\alpha)U] \tag{7}
\]

\[
U_K = \beta_K \frac{(m - g_K)}{[1-\delta(1-\beta_K)]} \tag{8a}
\]

\[
U_L = \beta_L \frac{(V - m - g_L)}{[1-\delta(1-\beta_L)]} \tag{8b}
\]

\( U_K \) is the present value obtained by a departing member from the sale of her membership rights in a firm, and \( U_L \) is the present value obtained by searching for a new position. It is often more illuminating to split the present value \( U \) in a slightly different way. Define

\[
\underline{U}_K = U_K + \beta_L \delta(1-\alpha)U_K/(1-\delta)[1-\alpha\delta(1-\beta_L)] \tag{9a}
\]

\[
\underline{U}_L = U_L - \beta_L \delta(1-\alpha)U_K/(1-\delta)[1-\alpha\delta(1-\beta_L)] \tag{9b}
\]

Thus \( \underline{U}_K + \underline{U}_L = U_K + U_L = U \). The underscored present values are pure returns to capital and labor from the search process, netting out the income associated with future sales of membership rights from \( U_L \) and treating this instead as a return to capital.

Profit flows are defined as in equations (3) and (4).
\[ z_K = (1-\alpha\delta)(m - g_K) \]  
\[ z_L = pq(e)/n - c(e) - (1-\alpha\delta)(m + g_L) \]  
\[ z(e) = z_K + z_L = pq(e)/n - c(e) - (1-\alpha\delta)G \]

Let \( \eta \equiv [1-\delta(1-\beta_L)]/[1-\delta(1-\beta_K)] \). Solving for \( V, U_K, \) and \( U_L \) from (7) and (8), switching to \( U_K \) and \( U_L \), and substituting for \( (z_K,z_L) \) from (10) gives

\[ U_K = \eta\beta_Kz_K/(1-\delta)[1-\alpha\delta(1-\beta_L)] \]  
\[ U_L = \beta_Lz_L/(1-\delta)[1-\alpha\delta(1-\beta_L)] \]

The solution for \( U_L \) in (12b) is identical to \( U_L \) in (5b). The expression for \( U_K \) in (12a) differs from \( U_K \) in (5a) in two ways: first, by the multiplicative constant \( \eta \), which exceeds unity when \( \beta_L > \beta_K \) and is less than unity in the reverse case; and second, because the denominator of \( U_K \) in (12a) involves the labor search parameter \( \beta_L \) rather than the capital search parameter \( \beta_K \) as in equation (5a). For notational simplicity define

\[ \Delta \equiv \left\{ \beta_K/(1-\alpha\delta)(1-\beta_K) \right\} \cdot \left\{ [1-\delta(1-\beta_K)]/[1-\alpha\delta(1-\beta_K)] - [1-\delta(1-\beta_L)]/[1-\alpha\delta(1-\beta_L)] \right\} \]

The analogs to equations (6a) and (6b) can now be written as

\[ V_K - U_K = (1-\beta_K)z_K/[1-\alpha\delta(1-\beta_K)] - m + g_K + \Delta z_K \]  
\[ V_L - U_L = (1-\beta_L)z_L/[1-\alpha\delta(1-\beta_L)] + m + g_L \]

These are the pure continuation surpluses to capital and labor, where by construction \( V_K + V_L = V \) and \( U_K + U_L = U \). The labor surplus in (13b) is identical to (6b), but the capital surplus in (13a) differs from (6a) by the term \( \Delta z_K \). The coefficient \( \Delta \) is positive if capital is scarce (\( \beta_K > \beta_L \)) and negative if labor is scarce (\( \beta_K < \beta_L \)).

**Proposition 2** (joint ownership economy). The effort \( e \geq 0 \) and profit division \( (z_K,z_L) \) with \( z_K + z_L = z(e), z_K \geq 0, \) and \( z_L \geq -z_K\delta(1-\alpha)\beta_K/(1-\alpha\delta)(1-\delta(1-\beta_K)) \) can be supported by a
stationary, symmetric, and subgame perfect strategy \( \sigma \) with search, investment, and renewal in equilibrium, starting from a history where every firm has either \( n \) vacancies or no vacancies at the search stage, if and only if \((\theta_K + \alpha \delta \Delta)z_K + \theta_L z_L \geq T(e) - \alpha \delta G\). This is equivalent to \( \alpha \delta (V - U) \geq T(e) \).

**Proof.** Available from the author upon request.\(^7\)

Assuming \( s = 1/n \) applies in both cases, the only difference between the incentive constraints in Propositions 1 and 2 is the term \( \alpha \delta \Delta z_K \) in Proposition 2. The participation constraint \( z_K \geq 0 \) is identical since this is equivalent to \( U_K \geq 0 \) in both cases. But the labor participation constraint \( z_L \geq 0 \) from Proposition 1 is replaced in Proposition 2 by a weaker inequality \( z_L \geq -z_K \delta(1-\alpha)\beta_K/(1-\alpha \delta)[1-\delta(1-\beta_K)] \), which corresponds to \( U_L \geq 0 \) under joint ownership. This occurs because the returns to labor and capital are now bundled, so the participation constraint \( U_L \geq 0 \) is compatible with a negative profit flow to labor \( (z_L < 0) \) as long as the profit flow to capital \( (z_K > 0) \) is large enough to compensate.

Figure 3 compares the supportable distributions of profit for the outside and joint ownership economies when capital is scarce relative to labor \( (\beta_K > \beta_L) \). As in previous graphs, the first best is assumed to be unattainable. Capital scarcity implies \( \Delta > 0 \) so the second-best frontier AC for joint ownership is to the right of the frontier AB for outside ownership whenever capital receives positive profit \( (z_K > 0) \). As in Figure 1, for any given isoprofit line there is a lower bound \( z_L^{\min}(e) \) on the profit stream going to labor, or an upper bound on profit going to capital. This distributional constraint is relaxed under joint ownership. When \( z_K = 0 \) so \( U_K = 0 \), the two frontiers converge at point A and profit is the same in both ownership systems. Points B and C where \( U_L = 0 \) holds under outside and joint ownership, respectively, are also on a common isoprofit line.

Figure 4 contrasts the two systems when labor is scarce relative to capital \( (\beta_K < \beta_L) \). Now \( \Delta < 0 \) so the joint ownership frontier AC is to the left of the outside ownership frontier AB. For a given isoprofit line there is an upper bound \( z_L^{\max}(e) \) on the profit flow going by labor, or a lower bound on the profit going to capital. This incentive constraint
is more relaxed in the outside ownership system. Again the frontiers coincide at point A where \( U_K = 0 \), and points B and C where \( U_L = 0 \) are located on the same isoprofit line.

The interactions among ownership, incentives, and the market environment run as follows. Assume first that capital is scarce. Outside owners can cheat on side payments and escape retaliation by firing innocent workers, who are easily replaced. Such cheating can only be deterred by ensuring that the owners do not find new matches too profitable. This upper bound on the profit going to capital implies a lower bound on the profit going to labor. Joint ownership relaxes this distributional constraint by bundling the supply of capital and labor. Under this system a worker cannot obtain any return on capital without first finding a job. Since jobs are few and far between, the implicit return to capital can be increased without triggering defections from equilibrium behavior.

Now suppose labor is scarce. A joint ownership system would tempt workers to shirk and quit because they can quickly buy their way into new firms. To deter this, it is necessary that workers not find new matches too profitable. This leads to an upper bound on the profit going to labor and thus a lower bound on profit to capital. The distributional constraint is relaxed for outside ownership, which divides these claims on the firm among separate agents. This deprives workers of returns on capital and makes new matches less attractive to them. It therefore becomes possible to pay out increased profit on pure labor contributions without inducing workers to exploit their scarcity by shirking and quitting. If capital has a zero return (\( z_K = 0 \)) or the market environment is symmetric (\( \Delta = 0 \)), these effects no longer matter and ownership becomes irrelevant.

As was mentioned at the end of section 3, when capital is scarce and vacancies are filled immediately \( \beta_K = 1 \) occurs. For generic inputs (\( G = 0 \)) the participation constraints \( U_K \geq 0 \) and \( U_L \geq 0 \) reduce to \( V \geq m \geq 0 \) in (8). By contrast with outside ownership where only non-positive fees (\( m \leq 0 \)) were possible for \( \beta_K = 1 \) and \( G = 0 \), under joint ownership only non-negative fees can arise. This is consistent with evidence that successful worker-owned firms often charge substantial membership fees (Estrin, Jones, and Svejnar, 1987; Craig and Pencavel, 1992), although conventional firms almost never do.

5. The Equivalence of Outside and Joint Asset Ownership
Sections 3 and 4 showed that outside and joint ownership economies differ in the restrictions they place on profit distribution. The fact that one second-best payoff frontier is uniformly further out than the other in Figures 3 and 4 may suggest that it is possible to achieve Pareto improvements by means of a transition from one ownership regime to the other. This impression is misleading. I show in this section that the ownership systems are equivalent: for each point on one frontier there is a unique point on the other frontier that gives every individual the same present value. The isomorphism emerges because the bundling or unbundling of capital and labor supply cancels out distributional effects resulting from shifts in the incentive constraint.

**Proposition 3** (equivalence). Assume $\beta_K \neq \beta_L$ so the second-best frontiers AB and AC in Figures 3 and 4 are distinct. For each $(z_K, z_L)$ on one frontier there is a unique $(z_K', z_L')$ on the same isoprofit line which is located on the other frontier. These two points have $V' = V$, $U_K' = U_K$, and $U_L' = U_L$.

**Proof.** The outside ownership frontier intersects each isoprofit line between points A and B once, and does not intersect any other isoprofit line. The joint ownership frontier from A to C has the same feature. Since B and C are on the same isoprofit line, for any $(z_K, z_L)$ on one frontier there is a unique $(z_K', z_L')$ on the other which yields identical total profit.

Choose two points on the same isoprofit line with $(z_K, z_L)$ on the outside ownership frontier and $(z_K', z_L')$ on the joint ownership frontier. Let $e \equiv e'$ be the effort level yielding total profit $z = z_K + z_L = z_K' + z_L'$. This effort is unique on $[0, e^*]$ because $z(e)$ is strictly increasing on this interval. The constraints from Propositions 1 and 2 can be written as $\alpha \delta (V-U) \geq T(e)$ and $\alpha \delta (V'-U') \geq T(e')$. Since both points are on their respective frontiers, $\alpha \delta (V'-U') = T(e') = T(e) = \alpha \delta (V-U)$ which implies that $V'-V = U'-U$.

Summing (1a) and (1b) gives $V = pq/n - c + \delta[\alpha V + (1-\alpha)U]$ while (7) gives $V' = pq'/n - c' + \delta[\alpha V' + (1-\alpha)U']$. Because $e' = e$ implies $pq'/n - c' = pq/n - c$, subtracting the first equation from the second gives $V'-V = \delta(1-\alpha)(U'-U)/(1-\alpha \delta)$. This is possible only if $V' = V$ and $U' = U$. Using $U' = U$ and manipulating (5), (9), and (12) it can be shown that $U_K' = U_K$ which implies that $U_L' = U_L$ holds as well.
Proposition 3 shows the equivalence of ownership systems from the standpoint of present values. The rest of this section develops stability and welfare implications. I will show that an efficient outside ownership economy cannot be destabilized through Pareto-improving transformations of individual firms to joint ownership or vice versa. However, firms with different property rights structures can co-exist.

Let \((z_K, z_L)\) be an equilibrium profit distribution with \(z_K + z_L = z(e)\) and let \((z_K', z_L')\) be a deviation from this distribution with \(z_K' + z_L' = z(e')\). This deviation may or may not involve a shift in ownership structure. I say that \((z_K', z_L')\) is a destabilizing deviation (DD) if it yields \(\alpha \delta (V' - U') \geq T(e')\), \(U_K' \geq U_K\), and \(U_L' \geq U_L\), where at least one of the latter two inequalities is strict. If the deviation involves outside asset ownership \(V', U_K', U_L'\) are computed as in (5) and (6), while if it involves joint ownership these present values are computed as in (9), (12), and (13).

The rationale for this definition is that in order to destabilize the prevailing market equilibrium, both newly matched workers and owners with newly filled vacancies must be at least as well off under the deviation, and some party must be better off. Both are at least as well off when \(U_K' \geq U_K\) and \(U_L' \geq U_L\) because these are the present values from a new match discounted to reflect search time. It can be shown that \(V' > V\) holds whenever at least one of these inequalities is strict, so the aggregate present value of a new match is larger under such deviations. By stationarity, if there are mutual gains from a deviation in one match then the same is true in all subsequent matches, so the parties should expect the deviation to be implemented in the future as well. This justifies the requirement that \(V', U_K', U_L'\) be computed as in (5) and (6), or alternatively as in (9), (12), and (13). Finally, \((z_K', z_L')\) must be supportable when repeated in all future matches. This is true if and only if \(\alpha \delta (V' - U') \geq T(e')\) as in Propositions 1 and 2.

**Corollary 1.** Consider any market equilibrium \((z_K, z_L)\) with outside ownership. There is a destabilizing deviation involving outside ownership if and only if there is some feasible \((z_K', z_L')\) that Pareto dominates \((z_K, z_L)\). If there is no DD with outside ownership, there is no DD with joint ownership. 'Joint' and 'outside' can be interchanged in these assertions.
Proof. Suppose \((z_K,z_L)\) is an equilibrium with outside ownership, and consider deviations \((z'_K,z'_L)\) that also involve outside ownership. If \((z'_K,z'_L)\) dominates \((z_K,z_L)\) then \((U'_K,U'_L)\) dominates \((U_K,U_L)\) by (5). If \((z'_K,z'_L)\) is also feasible then \(\alpha \delta (V' - U') \geq T(e')\) and \((z'_K,z'_L)\) is a DD. Conversely suppose there is no \((z'_K,z'_L)\) that is both feasible and dominates \((z_K,z_L)\), but there is a DD. This DD \((z'_K,z'_L)\) satisfies \(\alpha \delta (V' - U') \geq T(e')\) so it is feasible, and its present values \((U'_K,U'_L)\) dominate \((U_K,U_L)\). But then from (5) \((z'_K,z'_L)\) dominates \((z_K,z_L)\) which is false. Hence there is no DD involving outside ownership.

Suppose there is no DD involving outside ownership but there is a DD with joint ownership. This implies there is a \((z'_K,z'_L)\) satisfying \(\alpha \delta (V' - U') \geq T(e')\) with \((U'_K,U'_L)\) dominating \((U_K,U_L)\) where the present values are computed as in (9), (12), and (13). It can be assumed that \(\alpha \delta (V' - U') = T(e')\) holds, since otherwise \(z'_K\) or \(z'_L\) or both can be increased until equality holds without decreasing \(U'_K\) or \(U'_L\). By Proposition 3 there is a third distribution \((z''_K,z''_L)\) that is on the outside ownership frontier and yields \(U''_K = U'_K\) and \(U''_L = U'_L\). Because \((z''_K,z''_L)\) is on the outside ownership frontier it is feasible, and \((U''_K,U''_L)\) dominates \((U_K,U_L)\). This implies there is a DD with outside ownership, which is a contradiction. The proof starting from joint ownership is identical.

This corollary shows two things. First, to be stable an economy where all firms have the same property rights structure must be operating at an undominated point on its second-best frontier (recall that the frontier may have backward-bending segments). This is reassuring since there are many equilibria in Figures 3 and 4 that have inefficiently low effort. Propositions 1 and 2 show that these inefficient outcomes can be supported. But if one adds the restriction that an equilibrium not be open to any destabilizing deviations, all Pareto-dominated points are ruled out. This provides a "first welfare theorem" for an economy with self-enforcement.

Corollary 1 also shows that if an economy is stable with respect to deviations that leave firm ownership unchanged, it must be immune as well to voluntary transformations in the property rights structures of firms. But this stability property is weak since it only
rules out Pareto-improving deviations. Individual firms can still change property rights in ways that leave everyone indifferent, and mixed ownership systems can therefore arise.

**Corollary 2.** Consider an outside ownership economy where the profit division \((z_K,z_L)\) is not vulnerable to destabilizing deviations. Any subset of firms can be converted to joint ownership with an alternative profit division \((z'_K,z'_L)\) in such a way that all agents are left indifferent. The reverse is true starting from a joint ownership economy.

**Proof.** Since \((z_K,z_L)\) is not vulnerable to any DD, by Corollary 1 it is on the frontier for an outside ownership economy. By Proposition 3 there is a profit division \((z'_K,z'_L)\) on the frontier of the joint ownership economy with identical effort and profit which has \(V' = V\), \(U'_K = U_K\), and \(U'_L = U_L\). Let some subset of firms switch to joint ownership and operate at the point \((z'_K,z'_L)\). From Propositions 1 and 2 the incentive constraints are satisfied in each type of firm if \(\alpha \delta (V' - U') = T(e') = T(e) = \alpha \delta (V - U)\). But since \(V' = V\) and \(U' = U\) incentives are unaffected by the change in ownership. Unemployed workers are indifferent toward the type of firm they join because \(U'_L = U_L\), and asset owners with vacancies are indifferent toward ownership structures because \(U'_K = U_K\). Combining \(V' = V\), \(U'_K = U_K\), and \(U'_L = U_L\) with (2) and (8) yields \(m' - m = V_K\). Workers employed in an outside ownership firm can buy the asset at this price. The previous owner is indifferent while the workers exchange the present value \(V_L\) for an equal present value \(V' - (m' - m)\). The same argument is reversed starting from a joint ownership economy.

By Corollary 2 any combination of ownership structures can co-exist. The fact that stability is weak means that in the absence of other causal forces tending to favor one organizational form over the other, the mix of ownership structures arising in an economy is essentially a matter of social convention or historical accident.

Finally, some normative observations can be made. It has been shown that pure Pareto improvements cannot be achieved through ownership transitions if an economy is operating at an undominated point on its second-best frontier. A stronger requirement is
welfare maximization using the Kaldor-Hicks criterion. This amounts to maximization of total profit \( z(e) \) subject to incentive and participation constraints.

**Corollary 3.** When capital is scarce \((\beta_K > \beta_L)\) welfare is maximized at point A in Figure 3 where \( U_K = 0 \). When labor is scarce \((\beta_K < \beta_L)\) welfare is maximized at point B or C in Figure 4 where \( U_L = 0 \). In each case maximum welfare can be achieved through outside ownership, joint ownership, or any combination of the two.

**Proof.** If \( \beta_K > \beta_L \) then maximization of \( z(e) \) occurs at point A in Figure 3 regardless of the ownership structure of the economy. \( U_K = 0 \) follows from \( z_K = 0 \). If \( \beta_K < \beta_L \) then maximization of \( z(e) \) can be achieved at either point B or C since both are on the highest feasible isoprofit line. \( U_L = 0 \) follows from \( z_L = 0 \) at B, and holds at C by construction. The neutrality of ownership for welfare maximization follows as in Corollary 2.

The main point of Corollary 3 is that while ownership is neutral with respect to aggregate welfare maximization, the distribution of profit is not. If capital is scarce, all profit should go to labor, and if labor is scarce, all profit should go to capital. Although this may seem counterintuitive it follows naturally from the discussion in sections 3 and 4. Giving a larger present value to the more abundant input relaxes incentive constraints by reducing the temptation for cheating by suppliers of the scarce input. A slightly more subtle point is an implication about membership fees. When labor is scarce, efficiency in the Kaldor-Hicks sense requires that the labor participation constraint bind \((U_L = 0)\). In an outside ownership economy, workers must therefore have low enough wages or pay high enough fees to ensure they get no rent. Similarly, in a joint ownership economy newly matched members must pay a market-clearing entry fee so that they derive no net benefit from joining a firm. This would be inefficient in an economy with scarce capital where \( U_K = 0 \) is required for welfare maximization. In this environment membership fees for joint ownership firms should only cover the cost of match-specific capital \((m = g_K)\).

6. **Implications for the Theory of the Firm**
While it may seem obvious that reshuffling property rights to a fixed profit stream cannot alter effort incentives, this point has been overlooked in the modern theory of the firm. Contrary claims range from arguments that outside ownership is defective because owners will cheat employees to the notion that joint ownership is flawed because workers who cannot be fired will shirk. The equivalence of the two structures only becomes clear when they are compared within a unified analytic framework involving self-enforcement.

From another perspective, however, the neutrality of ownership is less surprising. There is a long literature establishing various 'equivalence' or 'isomorphism' relationships between capitalist and labor-managed firms, including Dreze (1989), Roemer (1988), Sertel (1982), and Dow (1986, 1996). Dreze shows that an economy consisting of labor-managed firms which maximize dividends per worker can be induced through corrective taxation to support the same allocations as a Walrasian economy. Roemer argues in a general equilibrium framework that an economy with worker-owned firms would simply replace profits to shareholders by interest payments to lenders. Sertel and Dow show that markets for membership in labor-managed firms induce such firms to maximize profit or present value. An economy with membership markets thus supports allocations identical to those in Walrasian theory. The neutrality results in this paper add self-enforcement to the list of environments where investor ownership is equivalent to worker ownership.

What is the point of an equivalence theorem? One purpose is to refute claims of the form "organizations of type x cannot work" by showing within a reasonable modeling framework that organizations of type x work as well as type y, where everyone agrees on the viability of type y. But a more serious goal is to assist in the search for explanations of empirical facts. There is a marked empirical asymmetry with respect to ownership: large physical assets such as oil refineries and auto assembly plants are virtually never owned jointly by the workers who use them, despite seemingly cogent economic reasons why this might occur. Instead these assets are ultimately owned by shareholders whose involvement in production activities is often negligible. An equivalence theorem can be useful because it suggests where not to look in trying to resolve this empirical puzzle. In particular, the results here cast some doubt on assertions that work incentives or asset specificity can account for biases toward outside ownership.
Minor variations on the modeling framework are unlikely to overturn this verdict. For instance, it could be argued that something essential is lost by having the firm's input suppliers observe one another's actions perfectly. Perhaps costly or imperfect monitoring along the lines discussed by Alchian and Demsetz (1972), Shapiro and Stiglitz (1984) and Bowles (1985) would drive a wedge between outside and joint ownership. However, if there are imperfect but publicly observed signals about effort supply, the noisiness of the signal simply increases the continuation surplus needed to keep agents on the equilibrium path (MacLeod and Malcomson, 1993). For monitoring to explain outside ownership, the outsiders would need to have systematically cheaper or more accurate ways of observing effort beyond what joint owners can achieve by monitoring each other (Putterman, 1984). This seems implausible. If the issue is the monitor's own incentive (Alchian and Demsetz 1972), then the monitor is a special kind of team member rather than a pure outsider.

Another extension involves assets whose value can be diminished by inadequate maintenance or overuse, in place of the indestructible assets examined here. Holmstrom and Milgrom (1991, 1994) show that misuse of assets can be curbed by combining high-powered effort incentives with asset ownership by workers, or alternatively low-powered incentives with ownership by outsiders. Their approach generates predictions about asset ownership if an external revenue claimant (the principal) is taken for granted.

In the Holmstrom and Milgrom model the only reason why it would be desirable to contract with a principal at all, rather than having workers receive revenue directly, is that principals are needed to provide insurance to risk averse workers. Setting insurance aside and retaining risk neutrality, the point that workers face two margins in supplying effort (producing output and maintaining assets) does not alter the thrust of the argument. In a world of self-enforcement the incentive constraint still involves a trade-off between gains from deviation and the loss of a continuation surplus when the current match ends. A reasonable conjecture is that outside and joint ownership will continue to be equivalent because there is conservation of surplus across systems: for given input levels the total continuation surplus is independent of property rights. If some workers specialize in the maintenance of assets while others specialize in production tasks ownership is unlikely to be neutral across workers, but again this departs from pure outside ownership.
The results derived here likewise call into question the role of asset specificity as a determinant of ownership structure, contrary to work by Hart (1995) and his co-authors as well as Dow (1993). Propositions 1 and 2 show that only the aggregate set-up cost of a new match is relevant for incentives, not match-specific investments for capital or labor separately. The total size of these sunk costs is also neutral across ownership systems. It would be easy to reformulate such investments as continuous variables and include them in the production function. These variables would be analogous to effort supply choices, and agents who deviated from equilibrium behavior could be punished by dissolving the match just as in the equilibria studied here. Moreover, self-enforced side payments can be used to shift the costs of specialized investments between the parties as desired. These considerations suggest that the property rights literature may have overstated the role of asset specificity and non-contractible investment as determinants of organizational form.

If effort incentives and asset specificity are doubtful contenders in explaining the empirical dominance of firms with outside ownership, what alternatives are available? In a survey of economic hypotheses concerning why worker-owned firms are rare, Dow and Putterman (1999) compiled a list of proposed explanations. Apart from work incentives and asset specificity, the most popular stories include limited worker wealth and credit rationing; worker risk aversion and portfolio diversification; and more severe collective choice problems in worker-owned firms than in firms owned by investors. There have been few efforts to discriminate among these hypotheses by confronting them with data.

The fact that large firms are almost universally owned and managed by investors or their agents, rather than by workers, is one of the most striking empirical regularities in economics. At least at first glance, this pattern conflicts with the proposition in the new institutional economics that unnecessary measurement or bargaining problems arise when an irrelevant outsider is brought into the production process, since non-human assets can be owned by workers. This reduces the number of transacting parties by at least one. If effort incentives or asset specificity lead to outside ownership, what do outside owners do that workers cannot do for themselves? If the explanation for outside ownership must be found elsewhere, which of the remaining theoretical stories is most convincing?
Notes

1. Bentley MacLeod, Gil Skillman, Vincent Crawford, Louis Puterman, Samuel Bowles, and Herbert Gintis commented on earlier drafts. Versions of this paper have been presented at the Universities of Montreal, Western Ontario, California-Riverside, California-San Diego, Southern California, Alberta, British Columbia, Victoria, and Simon Fraser University, and also at the Brookings conference on Human Capital and the Theory of the Firm, May 1997. The Swedish Collegium for Advanced Study in the Social Sciences, the Social Sciences and Humanities Research Council of Canada, and the Brookings Institution provided financial assistance. I would particularly like to thank Margaret Blair at Brookings for her encouragement. All opinions are those of the author.

2. Dissolution of the firm is the harshest possible penalty for deviation since worse punishments can be avoided by quitting (for workers) or firing all employees (for owners). Dow (1999) discusses the minimax properties of termination threats and develops the rationale for self-enforcement in the theory of the firm.

3. The following inequalities are necessary and sufficient for the transfers \((m,w,b)\) and effort \(e\) to be supportable.

   - **renewal:** \(V_K \geq U_K\) and \(V_L \geq U_L\)
   - **bonus:** \(-\alpha \delta (V_L - U_L) \leq b \leq \alpha \delta (V_K - U_K)\)
   - **effort:** \(b + \alpha \delta (V_L - U_L) \geq T(e|s)\)
   - **wage:** \(-(spq - c) - b - \alpha \delta (V_L - U_L) \leq w \leq (1/n - s)pq - b + \alpha \delta (V_K - U_K)\)
   - **fee:** \(w - (1/n - s)pq + b - \alpha \delta (V_K - U_K) \leq m \leq w + spq - c + b + \alpha \delta (V_L - U_L)\)
   - **investment:** \(g_K + w - (1/n - s)pq + b - \alpha \delta (V_K - U_K) \leq m\)
   - **search:** \(m \leq -g_L + w + spq - c + b + \alpha \delta (V_L - U_L)\)

To construct equilibrium strategies, use the side payments \(m_K = \max \{-m,0\}, m_L = \max \{m,0\}\); \(w_K = \max \{w,0\}, w_L = \max \{-w,0\}\); \(b_K = \max \{b,0\}, b_L = \max \{-b,0\}\). On the equilibrium path \(\sigma_K\) searches; invests \(g_K\) in every job; pays \(m_K\) to every worker; pays \(w_K\) to every worker; pays \(b_K\) to every worker; and renews every
worker. Off the equilibrium path, $\sigma_K$ searches; sets $g_K' = 0$ for every newly filled job if $m_L < g_K$, but invests $g_K$ if $m_L \geq g_K$; pays $m_K' = 0$ to every new worker; pays $w_K' = 0$ to every worker; pays $b_K' = 0$ to every worker; and fires every worker. On the equilibrium path $\sigma_L$ searches; invests $g_L$; pays $m_L$ to the owner; pays $w_L$ to the owner; supplies effort $e$; pays $b_L$ to the owner; and renews. Off the equilibrium path $\sigma_L$ pays $m_L' = 0$; pays $w_L' = 0$; supplies $e' = 0$; pays $b_L' = 0$; and quits.

4. If the first best effort $e^*$ is feasible for all profit distributions, the payoff frontier in Figure 1 is the isoprofit line for $z(e^*)$. If $e^*$ is feasible for some distributions $(z_K, z_L)$ of the profit $z(e^*)$ but not others, the frontier in Figure 1 coincides with the isoprofit line for $z(e^*)$ up to some $z_K^{\max}(e^*)$ and then follows a second-best curve below $z(e^*)$ for larger values of $z_K$. The potential cases can be distinguished as follows, regardless of whether $\beta_K > \beta_L$ or vice versa. Let $\beta_{\min} = \min \{\beta_K, \beta_L\}$ and $\beta_{\max} = \max \{\beta_K, \beta_L\}$. The effort $e^*$ is never feasible if $\max e' \left[\frac{pq(e', e^*)}{n} - c(e')\right] > \left[\frac{pq(e^*)}{n} - c(e^*) + \alpha \delta \beta_{\min} G\right]/\left[1 - \alpha \delta (1 - \beta_{\min})\right]$. This is true for small enough values of $\alpha \delta$. The effort $e^*$ is feasible for some but not all $(z_K, z_L) \geq 0$ such that $z_K + z_L = z(e^*)$ if $\frac{pq(e^*)}{n} - c(e^*) + \alpha \delta \beta_{\min} G\left[1 - \alpha \delta (1 - \beta_{\min})\right] \geq \max e' \left[\frac{pq(e', e^*)}{n} - c(e')\right] > \left[\frac{pq(e^*)}{n} - c(e^*) + \alpha \delta \beta_{\max} G\left[1 - \alpha \delta (1 - \beta_{\max})\right]\right]$. The effort level $e^*$ is feasible for all $(z_K, z_L) \geq 0$ such that $z_K + z_L = z(e^*)$ if $\frac{pq(e^*)}{n} - c(e^*) + \alpha \delta \beta_{\max} G\left[1 - \alpha \delta (1 - \beta_{\max})\right] \geq \max e' \left[\frac{pq(e', e^*)}{n} - c(e')\right]$ which is true for $\beta_{\max}$ near zero and $\alpha \delta$ near unity. The latter conclusion resembles the Folk Theorem idea that efficient outcomes can be supported in a repeated game when the players are sufficiently patient, but observe that if $\beta_{\max} = 1$ and $G = 0$, even $\alpha \delta = 1$ cannot support the effort $e^*$. The use of stationary strategies in conjunction with immediate rematching may make it impossible to deter deviations from $e^*$ even in the absence of discounting.

5. In a model similar to the one in section 3, MacLeod and Malcomson (1998) show that when capital is scarce effort will be obtained through efficiency wages, but if labor is scarce bonuses will be used instead. Despite various differences between the models, their incentive constraint is essentially the same as in Proposition 1.
6. Given some \((z_K, z_L)\) with \(z_K + z_L = z(e)\), any net fee \((m)\) can be selected as long as the renewal constraints (6) are satisfied. Along the frontier in Figures 1 and 2 the net bonus is maximized subject to incentive compatibility for the asset owner, so
\[
b = \alpha \delta (V_K - U_K) = \alpha \delta \{(1 - \beta_K)z_K/[1 - \alpha \delta (1 - \beta_K)] - m + g_K\} \geq 0.
\]
Thus owners may pay bonuses to workers but not conversely. For the given \((z_K, e)\) and chosen \((m, b)\), the wage must satisfy
\[
w = -z_K + \left(1/n - s\right)pq(e) - b + (1 - \alpha \delta)(m - g_K).
\]
When the economy is on the second-best frontier and \(s = 1/n\) (temptations for shirking are minimized) it can be shown that \(w\) is non-positive so workers rent assets from owners.

7. The following inequalities are both necessary and sufficient for the fee \(m \geq g_K\) and effort \(e \geq 0\) to be supportable.

- **renewal:** \(V \geq U\)
- **effort:** \(\alpha \delta (V - U) \geq T(e)\)
- **fee:** \(pq/n - c + \alpha \delta (V - U) + \delta U_K \geq m - g_K\)
- **investment:** \(pq/n - c + \alpha \delta (V - U) + \delta U_K \geq m + g_L\)
- **search:** \(U_L \geq 0\) and \(U_K \geq 0\)

On the equilibrium path \(\sigma\) searches; invests; pays \(m - g_K\); supplies \(e\); and renews.

Off the equilibrium path \(\sigma\) sets \(m' - g_K' = 0\), \(e' = 0\), and quits.
References


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