A Theory of Firm Boundaries with Long-Run Incentives and At-Will Employment*

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Abstract: Existing theories of the firm define its boundaries through the optimal allocation of ownership rights of alienable capital. However, a broad set of business services today rely on inalienable, i.e. human, capital. We provide a new theory of firm boundaries based on dynamic incentives and at-will employment. In our model, in each period, a principal can either write a short-term outsourcing contract in which parties commit to end the relationship after one period, or an employment contract that potentially lasts multiple periods. In environments in which an employee's past success increases his cost of effort in future periods, the principal's lack of commitment to re-hire an employed worker undermines her ability to provide incentives in earlier periods. Hence, in equilibrium, there is too much worker turnover and too much outsourcing relative to the first-best assignment of workers to firms. We characterize when outsourcing contracts strictly outperform employment contracts, and vice-versa. Notably, our theory does not rely on capital ownership, heterogeneous adjustment costs, or pre-existing boundaries, cornerstones of existing theories of the firm.

Key Words: Firm Boundaries, Moral Hazard, Outsourcing

JEL codes: D23, D86, J41

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1 Introduction

The preeminent theories of firm boundaries rely on incomplete contracts and the ownership of alienable assets. Under contractual incompleteness, the Coase theorem does not hold and asset ownership matters for efficiency. Ownership provides non-contractible decision rights and/or access to non-contractible returns on the asset. Once the firm is defined as a collection of assets with common ownership over them, firm boundaries are determined by the efficient allocation of decision rights and non-contractual returns. These theories cohere well with classical make-or-buy decisions for physical inputs. But, 83 percent of intermediate inputs purchased in the U.S. economy in 2018 are services.[1] And, as Zingales (2000) and Rajan and Zingales (2001) have previously argued, it is hard to find an alienable asset whose ownership matters so much that it governs a manager's decision to hire versus outsource, say, a management consultant.

This paper provides a theory of firm boundaries that does not rely on asset ownership. We posit a novel principal-agent model with at-will employment in which outsourcing provides a commitment to end the relationship after one period, whereas continued employment provides savings on adjustment costs. We show that if successfully completing a task today results in higher effort costs tomorrow, then the principal's inability to commit to retain an employed worker undermines her ability to provide incentives. Hence, outsourcing contracts may strictly outperform employment contracts, even when the latter are efficient.

Before describing the model and results in more detail, it is helpful to fix ideas with a concrete example. Consider the task of an internal auditor. When the auditor successfully completes his task, he potentially implicates his subordinates, coworkers, higher-ups, and, perhaps, himself. Hence, an employee assigned to complete the audit may

[1] See the Integrated Industry-Level Production Account (KLEMS) of the Bureau of Economic Analysis. Similarly, Atalay et al. (2014) report that about half of the upstream establishments report no shipments of tangible inputs to downstream establishments within the same firm.

choose not to be as thorough, considering how the audit impacts his long-term employment inside the firm. An external auditor, on the other hand, does not share the same concern because he commits to leaving the firm after the audit.

We study this type of incentive problem through the lens of a two-period principal-agent model in which, in each period, the principal chooses whether to outsource or write an employment contract. In an outsourcing contract, parties commit to a one-period relationship. The principal thus incurs an adjustment cost to find a new employee in period two. An employment relationship saves on adjustment costs, but an agent's successful completion of his task affects his cost of effort tomorrow, as in the auditor example. Moreover, at-will employment laws mean the principal can always hire a more attractive outsourced agent should he become available in period two, i.e. the contracts the principal offers must be re-negation proof.

When successful task completion today lowers the expected cost of effort tomorrow, dynamic incentives of the principal and agent are aligned. However, when success today increases the expected cost of effort tomorrow, as in the auditor example, the agent has dynamic incentives to shirk today in order to reduce his chance of being replaced tomorrow. An outsourcing contract, through its commitment to limit the relationship to one period, eliminates these perverse incentives. Thus, the principal is more easily able to incentivize effort in the first period. As long as adjustment costs are not too large, outsourcing thus outperforms an employment relationship.

Our analysis proceeds as follows. First, we characterize the first-best worker-task assignment (Proposition 1). We show that replacing an agent who fails in the first period is never efficient, while replacing an agent who succeeds in the first period is efficient if the cost of finding a new agent is smaller than the difference in the effort cost across the two periods.

We then characterize the principal's equilibrium choice of contract in terms of the model parameters (Proposition 2). The principal either (1) signs an employment contract in period one and always retains the worker, (2) signs an employment contract in period one and only retains the worker after low output, or (3) signs an outsourcing contract in period one. To decide whether to retain an employed worker, the principal compares the cost of finding a new agent to the cost of incentivizing effort in the second period. To decide whether to sign a "contingent employment" contract or an outsourcing contract, on the other hand, the principal compares adjustment costs to the dynamic rents the agent extracts in period one.

We observe that equilibrium contracting need not be efficient (Corollary 1) . In particular, the first-best worker-firm assignment is incompatible with outsourcing because outsourcing requires replacing an agent after failure. Yet, the principal chooses outsourcing for a non-trivial range of parameters of the model. Furthermore, there are parameters in which the equilibrium contract replaces an employed agent after success, while the first-best assignment retains them. In summary, the equilibrium contracting strategy often generates too much worker turnover and too much outsourcing relative to the efficient benchmark.

While our modeling is tailored to the auditor example, the general tension between dynamic incentives and commitment we identify appears relevant in a host of other problems. We suggest here two others. First, consider the task of internal capital allocation, a problem studied extensively in the literature on corporate finance.[2] A branch that receives a large share of resources today is likely to be more important to the firm tomorrow. Thus, a branch manager can be expected to overstate the resources needed in his branch for personal gains in the future. A management consultant, on the other hand, has better incentives because he expects little private gain from a growing branch. Second, consider an employer tasked with operating a new machine that might potentially be used to automate other tasks. The in-house operator may have incentives to misreport the machine's

[2]See Stein (2003) for a review of the related literature.

productivity — or sabotage the machine outright — if he or his co-workers face the risk of unemployment or reduced importance with successful automation. For example, in a retailer that is evaluating the performance of self-checkout machines, employed staff may be less willing to attend to problems generated by the machines or may overstate how frequently the machines malfunction.[3] An outsourced temp worker, on the other hand, would be less concerned about the future implications of automation if he expects to leave after performing his task.

1.1 Literature

This paper contributes to the strands of literature on firm boundaries and labor demand. There are three formal theories of the firm, all of which rely on incomplete contracts and asset ownership. We describe each and compare and contrast them with our model. The Property Rights Theory (PRT) introduced in Grossman and Hart (1986) and Hart and Moore (1990)[4] treats asset ownership as a tool to allocate residual decision rights for states of the world where contracts cannot be written or enforced. In PRT, asset ownership improves the outside option, thus, the surplus share of the owner. Hence, the asset owner faces a weaker hold-up problem and has better incentives to make ex-ante relation specific investments. The efficient distribution of productive assets optimizes the incentives to make relationship specific investments. The model prescribes hiring (make) when the firm's investments are more important and outsourcing (buy) when the agent's investments are more important. Importantly, ex-post decision making is efficient, even though it is not contractible. The inefficiency comes from the ex-ante investments. Similarly, in our model, the second period contracting is efficient although it is non-contractible and the inefficiency appears in the first period contract design. In contrast, in our model, it is the commitment power that makes outsourcing useful and not the residual control rights

[3]See Krueger and Mas (2004), Mas (2006), and Mas (2008) for evidence of explicit worker sabotage.
[4]See Gibbons (2005) and Dessein (2014) for a broader review of the theoretical contributions.

that follow capital ownership.

The second main theory of firm boundaries is the Multitask Incentive Theory (MIT) developed in Holmstrom and Milgrom (1991) and Holmstrom and Milgrom (1994). In MIT, a principal (she) motivates a risk-averse agent (he) to allocate his effort across a multitude of tasks. When the effort can only be measured with noise, the principal needs to trade off providing high-powered incentives with minimizing the income risk of the agent. Asset ownership can be used as a tool to provide incentives. When keeping the asset valuable is important, the efficient incentive structure dictates that the agent owns the asset, while if other tasks are more important, the principal should own the asset. MIT thus uses ex-post non-contractibility to generate firm boundaries. Again, an alienable asset is at the center of the theory. Asset ownership is not important because it provides control over its use here, but because it gives the rights to the non-contractible returns on the assets. While we also build on a principal-agent structure, our setting does not include the main building blocks of MIT, i.e. effort allocation across tasks and capital maintenance.

The third main theory of firm boundaries builds on the literature on delegation (Stein (1997), Aghion and Tirole (1997) and Dessein (2002)). Similar to PRT, ownership provides the rights to make decisions on the use of the asset. Unlike PRT, these rights are exercised in equilibrium. The principal trades off making a decision herself versus delegating the decision to an agent who is better informed, but has perverse incentives and cannot credibly communicate his information to the principal.[5] While this trade off is silent on the firm boundaries at its core, it can speak to it if some decision rights can only be assigned to the asset owner. The efficient allocation of the assets optimizes the allocation of decision rights across agents.[6] Although we set our model up to be about effort provision, it can be reformulated as a model of communication and decision making. The dynamic

[5] Alonso et al. (2008), among others, conceptualize the problem as a CEO contemplating delegating decision rights to a branch manager. Then, the problem can be posited as the trade-off between adaptation (to local conditions) and coordination (between firm branches).

[6] See Baker et al. (2006) as a formalization of the argument.

moral hazard problem we highlight occurs when truthful communication today has negative effects on the agent tomorrow. In contrast to the literature, our model would define boundaries without capital ownership and the associated decision rights.

Finally, we contribute to the theoretical literature on dynamic contracts. Much of this literature focuses on the role of long-term contracts in facilitating intertemporal risk-sharing (Rogerson (1985) and Spear and Srivastava (1987)). We shut off such advantages of employment relationships by considering a setting in which both the principal and agents are risk-neutral. In particular, in Appendix B, we show that short-term contracts can replicate the performance of any long-term contract (see Fudenberg et al. (1990) for general conditions under which short-term contracts suffice). Instead, we focus on the effects of the principal's endogenously determined re-negation opportunities on the optimal provision of incentives and choice of labor inputs.

2 A Two-Period Model

2.1 Environment

Setup. There is a risk-neutral principal who has one task to be completed in each of the two periods, $t = 1, 2$. In each period, she either writes an employment contract or an outsourcing contract with an agent from a large pool of risk neutral agents who are protected by limited liability. Each new contract, outsourcing or employment, costs $\phi > 0$ to sign.

In each period t, the agent can exert effort $e_t \in \{0, 1\}$, where 0 corresponds to shirking and 1 corresponds to working, to produce output $y_t \in \{\underline{y}, \overline{y}\} := Y$, where $\underline{y}$ corresponds to failure and $\overline{y} > \underline{y}$ corresponds to success. Effort e_t results in success with probability p_{e_t}, where $p_1 > p_0$. For a new agent, the cost of working is $c > 0$ and the cost of shirking is zero. If an employed agent continues their employment in period 2, the cost of effort depends on success or failure in the first period.[7] In particular, if $y_1 = \underline{y}$, then the cost of effort remains $c > 0$ in period 2, while if $y_1 = \overline{y}$, then it is θ. We assume, throughout, that $\overline{y} - \underline{y}$ is sufficiently large relative to the other parameters that the principal always desires to hire some worker in each period and implement work.[8]

The preferences of all parties in the model are represented by the discounted sum of expected per-period payoffs. The ex-post payoff of an agent in period t is given by

$$w_t - c_t,$$

where $w_t \in \mathbb{R}_+$ is the dollar value of the transfer she receives and $c_t \in \{c, \theta\}$ is the cost of effort. The principal's ex-post payoff in period t is

$$y_t - w_t - \phi_t,$$

where $y_t \in \{\overline{y}, \underline{y}\}$ is the output produced, $w_t \in \mathbb{R}_+$ is the transfer to the agent, and $\phi_t \in \{0, \phi\}$ is the search cost of hiring the agent (0 if re-hiring an employed worker and $\phi > 0$, otherwise). All parties have a discount factor of $\delta \in (0, 1)$.

Contracts. There are two types of contracts: employment contracts and outsourcing contracts. An employment contract has at-will termination. On the other hand, under an outsourcing contract, one (or both) side *commits* to end the relationship after the first period. The principal commits to a spot contract in each period t, i.e. a function $w_t : Y \to \mathbb{R}_+$, where wages are restricted to be non-negative to respect agent limited liability. We prove

[7] As the cost of effort depends on period 1's outcome, rather than the effort put forth by the agent, output is a sufficient statistic for effort in period 2.

[8] The exact condition required is:

$$\bar{y} - \underline{y} \geq \phi + \max\left\{\theta\left(\frac{p_1}{(p_1 - p_0)^2}\right), cp_1\left(\frac{1 + p_0}{(p_1 - p_0)^2}\right) + p_1\left(\frac{\theta - c}{p_1 - p_0}\right)\right\}.$$

that this restriction is without loss of generality in Appendix B.

2.2 The First-Best Assignment

The first-best worker-task assignment that prescribes high effort trades off the cost of signing a new contract, ϕ, and the additional effort the worker needs to undertake after a potential success, $\theta - c$.

Proposition 1. *In the efficient worker-task assignment, an employment relationship is developed in the first period and*

i. the worker is retained after failure;

ii. if $\phi \geq \theta - c$, the worker is retained after success; and

iii. if $\phi \leq \theta - c$, the worker is replaced after success.

We characterize the second-best worker-task assignment when the principal cannot observe effort and cannot commit to re-hiring an employed worker. To do so, we first identify the optimal outsourcing contract and then the optimal employment contract.

2.3 The Optimal Outsourcing Contract

The optimal outsourcing contract, $w_o^* = (w_o^*(\underline{y}), w_o^*(\overline{y}))$, solves the following wage-minimization problem:

$$\min_{w_o(\underline{y}), w_o(\overline{y})} \quad p_1 w_o(\overline{y}) + (1-p_1) w_o(\underline{y})$$

subject to

$$[IC_o] \quad p_1 w_o(\overline{y}) + (1-p_1) w_o(\underline{y}) - c \geq p_0 w_o(\overline{y}) + (1-p_0) w_o(\underline{y})$$

At the optimal contract, IC_o binds and wages are given by

$$w_o^*(\overline{y}) = \frac{c}{p_1 - p_0} \quad \text{and}$$
$$w_o^*(\underline{y}) = 0.$$

Hence, the agent's expected payoff is

$$U_o := c\left(\frac{p_0}{p_1 - p_0}\right) > 0$$

and the principal's expected payoff is

$$\Pi_o := p_1\left(\overline{y} - \frac{c}{p_1 - p_0}\right) + (1 - p_1)\underline{y}.$$

2.4 The Optimal Employment Contract

We now analyze employment contracts, starting from period 2.

Period 2. If the same agent is employed for a second period after having produced $\underline{y}$ in period 1, or if a new agent is hired as an employee, the cost of effort is c. Hence, the optimal spot contract is identical to the optimal outsourcing contract, yielding the principal a period 2 profit of

$$\Pi_e^2(\underline{y}) := \Pi_o.$$

If the employed agent is hired in period 2 after having produced $\overline{y}$ in period 1, his cost of effort is $\theta > c$. Optimal wages are thus given by

$$w_2^*(\overline{y}) = \frac{\theta}{p_1 - p_0} \quad \text{and}$$
$$w_2^*(\underline{y}) = 0,$$

yielding the principal a period 2 profit of

$$\Pi_e^2(\overline{y}) := p_1\left(\overline{y} - \frac{\theta}{p_1 - p_0}\right) + (1 - p_1)\underline{y} < \Pi_o.$$

Period 2 Contracting Decision. Since $\phi > 0$, the principal always retains the employed agent after she produces $\underline{y}$. On the other hand, the principal only retains the employed agent after she produces $\overline{y}$ if the cost of finding a new agent outweighs the gain from contracting with an agent with a lower cost of effort,

$$\phi \geq \Pi_e^2(\underline{y}) - \Pi_e^2(\overline{y}) = (\theta - c)\left(\frac{p_1}{p_1 - p_0}\right).$$

Period 1. The agent takes into account the principal's period two hiring/outsourcing decision when deciding how much effort to exert in period 1. There are two cases to consider: (a) the principal retains the agent whether or not she produced $\underline{y}$ and (b) the principal fires the agent when she produces $\overline{y}$ and retains the agent when she produces $\underline{y}$. In case (a), the optimal period 1 contract is equivalent to the optimal outsourcing contract; the contract offered in period 2 is unaffected by the agent's period 1 performance. In case (b), however, the optimal period 1 contract implementing effort must satisfy the dynamic incentive constraint

$$[IC_e] \quad p_1 w_1(\overline{y}) + (1 - p_1)(w_1(\underline{y}) + \delta U_o) - c \geq p_0 w_1(\overline{y}) + (1 - p_0)(w_1(\underline{y}) + \delta U_o).$$

At the optimal contract, IC_e binds and wages are given by

$$w_1^*(\overline{y}) = w_o^*(\overline{y}) + \underbrace{\delta\left(\frac{cp_0}{p_1 - p_0}\right)}_{\text{Dynamic Rent}} \quad \text{and}$$

$$w_1^*(\underline{y}) = 0.$$

The principal's first period profit is thus

$$p_1 \left(\overline{y} - c \left(\frac{1 + \delta p_0}{p_1 - p_0} \right) \right) + (1 - p_1)\underline{y}.$$

The Optimal Contract. If $\phi \geq \Pi_e^2(\underline{y}) - \Pi_e^2(\overline{y})$, then the optimal employment contract lasts two periods; the agent is hired in period 2 no matter her output in period 1. In addition, the agent receives the optimal spot contract in period 1 and in period 2. If $\phi < \Pi_e^2(\underline{y}) - \Pi_e^2(\overline{y})$, then the agent is re-hired in period 2 only if her period 1 output is $\underline{y}$. Providing incentives for effort in period 1 thus requires giving the agent additional rents.

2.5 Result

The following Proposition characterizes the optimal contracting strategy.

Proposition 2. *The principal's contract strategy is fully characterized by the following properties.*

i. *(Long Term Employment is Optimal)*
   If
   $$\phi \geq (\theta - c) \left(\frac{p_1}{p_1 - p_0} \right),$$
   then the principal optimally writes an employment contract in period 1 and re-hires the agent in period 2 whether or not he succeeds.

ii. *(Contingent Employment is Optimal)*
   If
   $$\phi < (\theta - c) \left(\frac{p_1}{p_1 - p_0} \right) \quad \textit{and} \quad \phi \geq c \left(\frac{p_1}{1 - p_1} \right) \left(\frac{p_0}{p_1 - p_0} \right),$$
   then the principal optimally writes an employment contract in period 1 and re-hires the agent in period 2 only if he fails in period 1. If he, instead, succeeds, the principal fires the agent in period 2 and contracts with another agent.

iii. (Outsourcing is Optimal)

If

$$\phi < (\theta - c)\left(\frac{p_1}{p_1 - p_0}\right) \quad \textit{and} \quad \phi < c\left(\frac{p_1}{1 - p_1}\right)\left(\frac{p_0}{p_1 - p_0}\right),$$

then the principal outsources an agent in period 1 and contracts with another agent in period 2.

Proof. See Appendix A for all proofs. □

We make a number of observations. First, for tasks in which $\theta < c$, i.e. those for which initial success makes the agent more adept, signing an employment contract and retaining the worker is optimal. This is a reasonable assumption in many cases and is consistent with employment being the dominant worker contract for firms.[9] Second, for tasks in which θ is sufficiently larger than c, the contract choice in the first period depends on the relative sizes of the dynamic rents and the cost of signing a new contract in the second period. If the dynamic rents are sufficiently large, the firm finds it too costly to motivate a worker to perform well. Third, the strict advantage of the outsourcing contract comes from its commitment power. If the worker knows that the contract will end, then it becomes easier to implement high effort. Finally, if $\frac{\theta}{c} < 1 + \frac{p_0}{1-p_1}$, then there is no value of ϕ for which contingent employment can arise as an optimal contracting strategy.

2.6 Efficiency of the Equilibrium Contract

Unlike the efficient worker-task assignment that trades off the cost of signing a new contract, ϕ, and the additional effort the worker needs to undertake after a potential success, $p_1(\theta - c)$, the principal also considers the dynamic rents captured by the agent in the employment contract. This leads to wedge between the efficient worker-task assignment and the equilibrium contract, as summarized in Corollary 1.

[9] In 2019, about 11% of the U.S. workers were employed by labor outsourcing providers (Bostanci, 2021).

Corollary 1. *The following properties hold in equilibrium.*

i. There is excess turnover relative to the first-best assignment:

(a) If

$$\theta - c \leq \phi \leq (\theta - c)\left(\frac{p_1}{p_1 - p_0}\right),$$

then the principal replaces an employed worker that is successful in period one, even though it is efficient to retain him.

(b) It is always efficient to retain a worker that fails in period one, but if

$$\phi \leq \min\left\{c\left(\frac{p_1}{1-p_1}\right)\left(\frac{p_0}{p_1 - p_0}\right), (\theta - c)\left(\frac{p_1}{p_1 - p_0}\right)\right\},$$

then the principal always replaces him in equilibrium.

ii. The principal outsources too much:

(a) If

$$\phi \leq \min\left\{c\left(\frac{p_1}{1-p_1}\right)\left(\frac{p_0}{p_1 - p_0}\right), (\theta - c)\right\},$$

then the principal outsources in period one even though it is efficient to write an employment contract in period one and retain the worker when he fails.

(b) If

$$\theta - c \leq \phi \leq \min\left\{c\left(\frac{p_1}{1-p_1}\right)\left(\frac{p_0}{p_1 - p_0}\right), (\theta - c)\left(\frac{p_1}{p_1 - p_0}\right)\right\},$$

then the principal outsources in period one even though it is efficient to write an employment contract and retain the worker in period two no matter her success or failure in period one.

Figure 1 illustrates the parameter regions identified in Corollary 1 with a numerical example. The line $y_1 : \phi = \theta - c$ divides the parameter set into two parts: above it, retaining a successful worker is efficient (the union of regions A, D, and E), while below

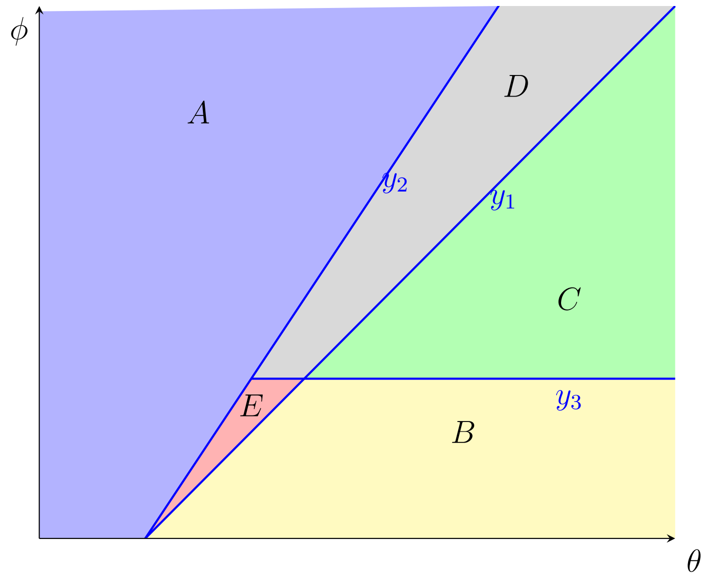

Figure 1: The Parameter Regions Characterized by the Efficiency and Equilibrium Conditions, $c = 1, p_0 = 0.25, p_1 = 0.75$

it, replacing him is efficient (the union of regions B and C). On the other hand, the line $y_2 : \phi = (\theta - c)\left(\frac{p_1}{p_1 - p_0}\right)$ creates two other parts: above it, the principal chooses long-term employment and retains the worker she hires in period 2 independently of his performance (region A), while, below it, she replaces him in period 2 (regions B, C, D, and E). Hence, in regions D and E, a successful worker is replaced even though it is efficient to retain him, as identified in (i.). The wedge between y_1 and y_2 arises because the transfer required to motivate the agent with high effort cost is larger than his disutility.

For $\phi < (\theta - c)\left(\frac{p_1}{p_1 - p_0}\right)$, the line $y_3 : \phi = c\left(\frac{p_1}{1 - p_1}\right)\left(\frac{p_0}{p_1 - p_0}\right)$ divides the parameter set into two parts: the principal chooses outsourcing in regions B and E, and chooses contingent employment in C and D. Because outsourcing replaces a failed worker in the second period, which is never efficient, there is too much worker turnover in regions B and E. Even though a long-term contract would be efficient for region E and a contingent contract would be efficient for region B, the principal chooses to outsource as shown in (ii.). The discrepancy stems from the presence of dynamic rents: while the efficient assignment compares the increase in effort cost arising from hiring a successful worker with the cost of signing a new contract, the principal needs to take into account the additional compensation needed to implement high effort in the first period.

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A Proofs

Proof of Proposition 1. For an employed agent, after failure in the first period, the cost of effort is identical to a new agent in the second period. Hence, the only difference is that bringing in a new agent has a cost of $\phi > 0$. Thus, keeping the same agent after failure creates strictly higher surplus. After success, an employed agent's cost of effort increases to θ. On the other hand, a new agent has only a cost of effort of c. Hence, the efficient assignment replaces the old agent only if $\theta - c \geq \phi$. Hiring an employed agent in period 1 always generates strictly higher surplus than hiring an outsourced agent since the former potentially saves on search costs in period 2 with positive probability ($p_1 > 0$). $\square$

Proof of Proposition 2. The principal's payoff from a sequence of optimal outsourcing contracts is

$$\Pi_o - \phi + \delta(\Pi_o - \phi).$$

If $\phi \geq \Pi_o - \Pi_e^2(\bar{y}) = p_1\left(\frac{\theta - c}{p_1 - p_0}\right)$, then the principal's payoff from the optimal employment contract is

$$\Pi_o - \phi + \delta\left(p_1\Pi_e^2(\bar{y}) + (1 - p_1)\Pi_o\right).$$

Since

$$\Pi_o - \phi \leq \Pi_e^2(\bar{y}),$$

we have that

$$\Pi_o - \phi < p_1\Pi_e^2(\bar{y}) + (1 - p_1)\Pi_o.$$

Hence, the employment contract strictly outperforms a sequence of outsourcing contracts.

On the other hand, if $\phi < \Pi_o - \Pi_e^2(\bar{y}) = p_1\left(\frac{\theta - c}{p_1 - p_0}\right)$, then the principal's payoff from the optimal employment contract is

$$p_1\left(\bar{y} - c\left(\frac{1 + \delta p_0}{p_1 - p_0}\right)\right) + (1 - p_1)\underline{y} + \delta\left(p_1(\Pi_o - \phi) + (1 - p_1)\Pi_o\right).$$

This yields the principal a higher payoff than a sequence of outsourcing contracts if and only if

$$\phi \geq c\left(\frac{p_1}{1-p_1}\right)\left(\frac{p_0}{p_1-p_0}\right).$$

□

B Optimality of Spot Contracting

In Section 2, we assumed that the principal was constrained to use spot contracts. We prove here that this assumption is without loss of generality, i.e. that she cannot do better with a fully contingent contract. A fully contingent contract is a pair of functions (w_1, w_2), where $w_1 : Y \to \mathbb{R}_+$ and $w_2 : Y^2 \to \mathbb{R}$. $w_1(y_1)$ specifies wages in period 1 as a function of observed output in period 1, y_1. $w_2(y_1, y_2)$ specifies wages in period 2 as a function of observed output in period 1, y_1, and in period 2, y_2.

We first show that if the principal credibly retains the agent for two periods, then she cannot do better than use a sequence of spot contracts. Define

$$U_1 := p_1 w_1(\overline{y}) + (1-p_1) w_1(\underline{y}) - c,$$

$$U_2(\overline{y}) := p_1 w_2(\overline{y}, \overline{y}) + (1-p_1) w_2(\overline{y}, \underline{y}) - \theta, \quad \text{and}$$

$$U_2(\underline{y}) := p_1 w_2(\underline{y}, \overline{y}) + (1-p_1) w_2(\underline{y}, \underline{y}) - c.$$

The optimal dynamic contract that implements work in both periods and always (credibly) retains the agent solves

$$\min_{w_1,w_2} \quad U_1 + \delta(p_1 U_2(\overline{y}) + (1-p_1)U_2(\underline{y}))$$

subject to

$$[IC_1] \quad U_1 + \delta(p_1 U_2(\overline{y}) + (1-p_1)U_2(\underline{y})) \geq p_0 w_1(\overline{y}) + (1-p_0)w_1(\underline{y}) + \delta(p_0 U_2(\overline{y}) + (1-p_0)U_2(\underline{y}))$$

$$[IC_2(\overline{y})] \quad U_2(\overline{y}) \geq p_0 w_2(\overline{y},\overline{y}) + (1-p_0)w_2(\overline{y},\underline{y})$$

$$[IC_2(\underline{y})] \quad U_2(\underline{y}) \geq p_0 w_2(\underline{y},\overline{y}) + (1-p_0)w_2(\underline{y},\underline{y})$$

$$[R(\overline{y})] \quad p_1 w_2(\overline{y},\overline{y}) + (1-p_1)w_2(\overline{y},\underline{y}) \leq p_1 \frac{c}{p_1-p_0} + \phi$$

$$[R(\underline{y})] \quad p_1 w_2(\underline{y},\overline{y}) + (1-p_1)w_2(\underline{y},\underline{y}) \leq p_1 \frac{c}{p_1-p_0} + \phi.$$

Since only the differences $w(\overline{y}, y_2) - w(\underline{y}, y_2)$, $y_2 \in \{\underline{y}, \overline{y}\}$, matter for first-period incentives, it is without loss of generality to set $w(\overline{y},\underline{y}) = w(\underline{y},\underline{y}) = 0$. The second-period constraints thus simplify to

$$\begin{aligned}
&[IC_2(\overline{y})] \quad w(\overline{y},\overline{y}) \geq \frac{\theta}{p_1-p_0} \\
&[IC_2(\underline{y})] \quad w(\underline{y},\overline{y}) \geq \frac{c}{p_1-p_0} \\
&[R(\overline{y})] \quad w(\overline{y},\overline{y}) \leq \frac{c}{p_1-p_0} + \frac{\phi}{p_1} \\
&[R(\underline{y})] \quad w(\underline{y},\overline{y}) \leq \frac{c}{p_1-p_0} + \frac{\phi}{p_1}.
\end{aligned}$$

From these constraints, we see that if

$$\phi < (\theta - c)\left(\frac{p_1}{p_1-p_0}\right),$$

then it is not possible to satisfy $IC_2(\overline{y})$ and $R(\overline{y})$ simultaneously, i.e. there is no incentive feasible contract that retains the agent in period 2 following success in period 1. If, on the other hand,

$$\phi \geq (\theta - c)\left(\frac{p_1}{p_1-p_0}\right),$$

then it is optimal to set $w(\underline{y}) = 0$. The first-period incentive constraint simplifies to

$$[IC_1] \quad w_1(\overline{y}) + \delta p_1(w_2(\overline{y},\overline{y}) - w_2(\underline{y},\overline{y})) \geq \frac{c}{p_1 - p_0} + \delta(\theta - c).$$

In light of this constraint and the principal's marginal rate of substitution between $w_2(\overline{y},\overline{y}) - w_2(\underline{y},\overline{y})$ and $w_1(\overline{y})$, she can do no better than use spot contracts, i.e. setting $w_2(\overline{y},\overline{y}) - w_2(\underline{y},\overline{y}) = 0$ and providing period 1 incentives solely through $w_1(\overline{y})$.

There are two other cases to consider. First, suppose the principal retains the agent only after failure. The optimal dynamic contract that implements work in both periods solves

$$\min_{w_1, w_2(\underline{y},\overline{y}), w_2(\underline{y},\underline{y})} \quad U_1 + \delta(1-p_1)U_2(\underline{y})$$

subject to

$$[IC_1] \quad U_1 + \delta(1-p_1)U_2(\underline{y}) \geq p_0 w_1(\overline{y}) + (1-p_0)w_1(\underline{y}) + \delta(1-p_0)U_2(\underline{y})$$

$$[IC_2(\underline{y})] \quad U_2(\underline{y}) \geq p_0 w_2(\underline{y},\overline{y}) + (1-p_0)w_2(\underline{y},\underline{y})$$

$$[R(\underline{y})] \quad p_1 w_2(\underline{y},\overline{y}) + (1-p_1)w_2(\underline{y},\underline{y}) \leq p_1 \frac{c}{p_1 - p_0} + \phi.$$

In any solution to this program, it must be that $w_1(\underline{y}) = w_2(\underline{y},\overline{y}) = 0$ (if not, then the principal could reduce wages by a small amount without affecting incentives and strictly increase her profits). The second-period constraints thus simplify to

$$[IC_2(\underline{y})] \quad w(\underline{y},\overline{y}) \geq \frac{c}{p_1 - p_0}$$

$$[R(\underline{y})] \quad w(\underline{y},\overline{y}) \leq \frac{c}{p_1 - p_0} + \frac{\phi}{p_1}.$$

On the other hand, the first-period constraint simplifies to

$$[IC_1] \quad p_1 w_1(\overline{y}) + \delta(1-p_1)p_1 w_2(\underline{y},\overline{y}) - c \geq p_0 w_1(\overline{y}) + \delta(1-p_0)p_1 w_2(\underline{y},\overline{y}),$$

which holds if and only if

$$[IC_1] \quad w_1(\overline{y}) \geq \frac{c}{p_1 - p_0} + \delta p_1 w_2(\underline{y}, \overline{y}).$$

In light of $IC_2(\underline{y})$, it is thus optimal to set $w_2(\underline{y}, \overline{y})$ as small as possible, i.e. equal to the optimal period 2 spot contract, so that $w_1(\overline{y})$ can be reduced by as much as possible. Hence, a sequence of spot contracts is optimal.

Second, suppose the principal retains the agent if she succeeds. The optimal dynamic contract that implements work in both periods solves

$$\min_{w_1, w_2(\overline{y},\overline{y}), w_2(\overline{y},\underline{y})} \quad U_1 + \delta p_1 U_2(\overline{y})$$

subject to

$$[IC_1] \quad U_1 + \delta p_1 U_2(\overline{y}) \geq p_0 w_1(\overline{y}) + (1 - p_0) w_1(\underline{y}) + \delta p_0 U_2(\overline{y})$$

$$[IC_2(\overline{y})] \quad U_2(\overline{y}) \geq p_0 w_2(\overline{y}, \overline{y}) + (1 - p_0) w_2(\overline{y}, \underline{y})$$

$$[R(\overline{y})] \quad p_1 w_2(\overline{y}, \overline{y}) + (1 - p_1) w_2(\overline{y}, \underline{y}) \leq p_1 \frac{c}{p_1 - p_0} + \phi.$$

In any solution to this program, it must be that $w_1(\underline{y}) = w_2(\overline{y}, \underline{y}) = 0$ (if not, then the principal could reduce wages by a small amount without affecting incentives and strictly increase her profits). The second-period constraints thus simplify to

$$[IC_2(\overline{y})] \quad w(\underline{y}, \overline{y}) \geq \frac{\theta}{p_1 - p_0}$$

$$[R(\overline{y})] \quad w(\overline{y}, \overline{y}) \leq \frac{c}{p_1 - p_0} + \frac{\phi}{p_1}.$$

If

$$\phi < (\theta - c)\left(\frac{p_1}{p_1 - p_0}\right),$$

then it is not possible to satisfy $IC_2(\overline{y})$ and $R(\overline{y})$ simultaneously. If, on the other hand,

$$\phi \geq (\theta - c)\left(\frac{p_1}{p_1 - p_0}\right),$$

then it is optimal to set $w(\underline{y}) = 0$. The first-period constraint simplifies to

$$[IC_1] \quad p_1 w_1(\overline{y}) + \delta p_1 p_1 w_2(\overline{y}, \overline{y}) - c \geq p_0 w_1(\overline{y}) + \delta p_0 p_1 w_2(\overline{y}, \overline{y}),$$

which holds if and only if

$$[IC_1] \quad w_1(\overline{y}) + \delta p_1 w_2(\overline{y}, \overline{y}) \geq \frac{c}{p_1 - p_0}.$$

In light of this constraint and the principal's marginal rate of substitution between $w(\overline{y}, \overline{y})$ and $w(\overline{y})$, she can do no better than setting $w_1(\overline{y}) = \frac{c}{p_1 - p_0}$ and $w(\overline{y}, \overline{y}) = \frac{\theta}{p_1 - p_0}$.