The Human Side of the Firms*

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Many typos and grammar errors, sorry! Comments are welcomed.

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Abstract

This paper explores the role of firm boundaries by abstracting from the property rights approach, which is not applicable to the increasingly important human-capital intensive firms. By focusing on firm boundaries' role as 'information barriers' that blur employees' individual outside identities, we find that firms boundaries matter because they can alter investment specifity and hence alleviate or aggravate the hold-up problem. Specifically, when there is substantial investment externalities integration is more efficient, and conversely separation is more efficient when investment externality is small. This main result is obtained under both Nash and alternating-offer bargaining, while optimal organization structure is characterized under the former. Finally, we also examine the effect of relational

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contracts and show that organization structures matter even when relational contracts can be signed.

1 Introduction

What difference does it make when a group of people work as one integrated firm instead of several separated firms? Common sense suggests that integration will facilitate better corporation among the group. This implies that there is externalities – one people's payoff depends on the actions of some other people. However, why does people behave differently when they belong to the same firm, aside from trivial reasons such as being physically closer to each other or psychological reason such as feeling as a big family? In this paper, we focus on a commonly observed phenomenon – when people join a firm they lose, to some extent, their individual identity to their customers so latter on if they were to decide to leave the firm, outside customers can not judge them soly by their individual performance (because the customers are not sure what their contributions are) instead each employee will be judged together with the rest of the firm. From this information-barriers perspective, we build a human-side theory of the firm and find that integration can alleviate hold-up problems when investment externalities are big and aggravate the problems when externalities are small.

It is commonly observed that when a group of people work together they intentionally blur their individual identities. For example, academic papers in economics are often published with the authors' name listed in alphabetical order instead of ranked by each author's contribution (Engers et al [3]). In industries, labor markets often can only recognize workers by the name of the firm they work for instead their true value because the common name of the firm, instead individual workers' name, are used to claim success or failure. For example, the managers of General Electric are often consider good managers by outside market sometime regardless their real abilities, whereas consultants or auditors of Author Anderson finds themselves hard to find a job elsewhere after the scandal of Enron even they are not related to the scandal. In addition to individual workers, the identify of a segment of a firm are often affected by the rest of the firm. For example, EDS is recognized to have an expertise in automotive industry because it was once owned by General Motor. After EDS is separated from General Motor, this recognition helped EDS winning a 10 year extensive contract with Rolls-Royce's in 1995. Although in some cases, judging a worker by the firm he works for or a segment by the firm it belongs to might give one a decent picture of its value, the important thing is that the picture is rarely 100% clear and, more interestingly, in many cases the picture is very vague.

The observation above helps us to find a new, human perspective to analyze the firm. In the existing literature, the property right approach to the theory of the firm pioneered by Grossman and Hart [4] and Hart and Moore [5] (henceforth GHM) has made a tremendous contribution in helping us to understand the firms and appreciate the relevance of property rights. The general theme of this literature is that, when contracts are incomplete, ownership of physical assets matters because it can alter the marginal return to investment and hence change the investors' incentive to invest[1]. By defining the firm as a collection of physical assets that it owns, this approach has a particular strength in assessing the cost and benefit of integration and different ownership structures. However, this focused view also make it lose sight of the human part of the firms, which is of particular importance for human-capital intensive firms such as law, consulting,

[1]Under the Nash bargaining structure of Grossman and Hart[4] and Hart and Moore[5], ownership can enhance manager's investment incentives. Whereas, under the alternating-offers bargaining structure of Chiu [2] and De Meza and Lockwood [8], ownership can hinder manager's investment incentives.

medicine, investment banking, advertising and accounting firms. The obvious difficulty is that human assets are inalienable and when one firm acquires the other the former does not own the human assets of the latter. This problem has been noticed in the literature (Zingales[11]), and some research has been devised to address it. For example Rajan and Zingales [9] and [10] define the firm as a set of unique assets and a group of people who have access to these assets.

In the current paper, we made a bold conceptual departure from the property right approach and define the firms in terms of people. In particular, we define a firm as a group of people who work together in a close way that outsiders identify with the firm but not with individual employees. Put it another way, we assume the boundaries of the firms as 'information garbling' devises that blur employees' individual outside identities. By this definition, we find that integration is more efficient when investment externalities are high (for example the value of one person's human capital increases rapidly with another person's effort) and negative when investment externalities are low. This main result is obtained under both Nash (GHM) and alternating-offer (Chiu [2] and De Meza and Lockwood [8]) bargaining, two leading bargaining strucutres used by the property right approach. Finally, we allow the investment game to be repeated so that parties can sign 'relational contracts' as defined by Baker, Gibbons and Murphy [1] and examine how organization structure, newly defined in the current paper, affect the feasibility of relational contracts.

Certainly, externalities plays an important role in real-life mergers – the word 'synergy' has been one of the most popular buzzwords used to justify mergers. From the standard, nonhuman-asset perspective, the idea that integration can internalize externalities is very well-known. For example, when two competing dualpolies are integrated and become one monopoly the joint producer surplus increases. The explanation of this standard perspective is trivial – integration simply transform a multi-person game into a single-person decision problem. However, if we view the firm as a group of people instead of assets, it is totally not clear why integration can internalize externalities since the problem is always a multi-person game, before or after integration.

One of the most significant mergers in business consulting is the one between IBM and PricewaterhouseCoopers' consulting practice (hence forth PwC). It is believed that this merger will help IBM, whose major revenue used to come from selling hardware, to reinvent itself as a high-level service provider. We will use the following imaginary story between IBM and PwC to illustrate the idea of this paper. Suppose that there is a project that requires a new business strategy (potentially from PwC) and a new computer system (potentially from IBM) to implement the strategy. Imaginably, IBM's investment in tailoring the computer system to fit the strategy has a big, positive externality on PwC's outside identity (outside option) because it enhances the impenetrability of PwC's strategy even when the strategy is implemented with a computer system provided by someone other than IBM. If PwC and IBM are two seperated firms, this enhanced identity accrues only to PwC since the market knows clearly that PwC is responsible for the strategy. On the other hand, if PwC and IBM are two segments of one integrated firm X, the market will be not so clear about who is responsible for the strategy (imagine PwC and IBM came to exist as one firm and on one knows about PwC and IBM individually. People only know firm X as a whole.) In this case, IBM might be able to capture some of PwC's identity , because if IBM were to be separated from PwC, people might think it is good at strategy, and hence provide better incentive for IBM to invest.

With the famous holdup problem in the background and hence underinvestment always exists, integration will be optimal if it induce a lot more investment from IBM without forgoing too much investment from PwC for losing it identity. Under situations where PwC's investment also has strong, positive externalities on IBM's outside identity, the optimality for integration is even more certain. However, separation can be optimal when externalities are small since sharing outside identities can only dilute investment incentives.

The literature specifically on human-capital intensive firm is relatively thin. One recent contribution is made by Levin and Tadelis [7] who address partnerships. The idea that personal identity (or sometime termed as reputation) can be transferred has receive some attentions (for example, Tadelis 99 AER and Mailath and Samuelson 01 RES) Also garbling information can improve efficiency is obtained in Dewatripont, Jewitt, and Tirole (1999) on career concerns. Investment externalities has been investigated by Che and Hausch 1999, De Fraja 1999, and Che 2000

The following of the paper is organized as follows. In Section 2 we present an one-shot investment game between two investors and the main results, which consider both Nash and alternating-offer bargaining structures. Section 3 considers the effect of repeating the investment game. Conclusion is in Section 4.

2 The One-shot (spot) investment game

2.1 Basic setup

A project requires the human capitals of two people A and B. Denote $a \in \mathbf{R}^+$ and $b \in \mathbf{R}^+$ as the investments that A and B make in this project. The private marginal costs of investments are unity. Assume that the total value of the project is the sum of the values of A and B's human capitals and denote them as $A(a,b)$ and $B(a,b)$ respectively. Assume also that $A_a > 0$ and $B_b > 0$. This reflects the idea that one person's investment has a positive externality on the other[2]. In addition, we assume that A_{aa}, A_{bb}, B_{aa}, $B_{bb} < 0$. Under the above setting, the first best investment which is a pair (a^*, b^*) such that

$$(a^*, b^*) = \arg\max A + B - a - b$$

or

$$A_a(a^*, b^*) + B_a(a^*, b^*) = 1 \tag{1}$$

and

$$A_b(a^*, b^*) + B_b(a^*, b^*) = 1.$$

To fix idea, one could imagine that the primary project is to solve a particular business problem that involves designing a new strategy and a new information technology, and A and B are two consultants who respectively have expertise in strategy and information technology. Quite possibly, A's investment in the information technology can enhance B's strategy and vise versa.

The primary project requires both A and B to agree to use their human capitals in the project. If they do, then a return which equals to $A(a,b) + B(a,b)$ will be paid jointly to A and B[3]. If they do not agree, each of them can use his human capital independently in a secondary project. However, the values of A and B's human capitals will be discounted in their respective secondary

[2] For simplicity, we do not consider negative externalities.

[3] This assumption reflects situation where overall output is more readily observed than its components.

projects because these secondary projects are less efficient uses of their human capitals. As a result the investments of A and B are *relationship-specific*, in the sense that they generate less value when A and B break up. Denote the values of A and B's human capitals in the secondary projects as $\underline{A}(a,b)$ and $\underline{B}(a,b)$, respectively, and assume that $\underline{A} = \phi A$ and $\underline{B} = \phi B$ where $\phi \in (0,1)$. The assumption that investment affect both $A(a,b)$ and $B(a,b)$ and $\underline{A}(a,b)$ and $\underline{B}(a,b)$ is to reflect that idea that people to build up valuable human capital is to be recognized not only inside the firm but also outside of the firm (labor market).

To formulate the information-barrier role of firm boundaries, we allow A and B to choose to not let the external labor market (which consists of potential customers of the secondary projects) clearly identify their respective human capitals. Denote $\alpha \in [0,1]$ as the probability the external labor market believes A is actually the owner her own human capital and $\beta \in [0,1]$ as the probability the external labor market believes B is actually the owner of his own human capital. We define integration and separation as follows.

Definition 1 *A and B are integrated if $\alpha < 1$ or $\beta < 1$ and say A and B are separated if $\alpha = 1$ and $\beta = 1$.*

By this definition, we will have a continuum of different types of integration and the difference between separation and some type of integration (when α and β are very close to one) can be very small. This definition allows us to parametrize all of possible organization structures (including separation) by the belief of the external labor market. So, in the following, we will refer to an organization structure with parameter (α, β) as $O(\alpha, \beta)$. Assuming that the external labor market will pay A and B the *estimated* value of their respective human capitals based on the market's belief, A and B's outside options under $O(\alpha, \beta)$ are $\alpha\underline{A} + (1-\beta)\underline{B}$ and $(1-\alpha)\underline{A} + \beta\underline{B}$

respectively. In essence, the reservation value of one's human capital become a mixture of the value of human capitals of everyone in the firm depending how the boundaries of the firm is setup, i.e. how α and β are chosen.[4]

A and B know that it is jointly more profitable for them to agree on the primary project but need to bargain over the joint return $A(a,b) + B(a,b)$ *after* they invest. This introduces the hold-up problem. In the following two section, we analyze the problem under two different bargaining structure: *Nash bargaining* and *alternating-offers bargaining.*

2.2 Nash Bargaining

In this section, we assume A and B bargain over the total surplus, $A(a,b) + B(a,b)$, in a 50-50 Nash bargaining game with their payoffs in the external labor market as reservation values. Given organization structure $O(\alpha, \beta)$, A's payoff is

$$\alpha \underline{A} + (1-\beta)\underline{B} + \frac{1}{2}\left[A + B - \underline{A} - \underline{B}\right] - a \tag{2}$$

and B's payoff is

$$(1-\alpha)\underline{A} + \beta\underline{B} + \frac{1}{2}\left[A + B - \underline{A} - \underline{B}\right] - b. \tag{3}$$

[4] Levin and Tadelis [7] take the defining feature of a parternership to be redistribution of profits among the parteners, we take the defining feature of the integration of firms to be redistribution of outside option among the firms.

A Nash equilibrium of this investment game is a pair of investment $\left(a^N, b^N\right)$ that satisfies the following first order conditions

$$\frac{1}{2}\left(A_a + B_a\right) + \left(\alpha - \frac{1}{2}\right)\underline{A}_a - \left(\beta - \frac{1}{2}\right)\underline{B}_a = 1 \tag{4}$$

$$\frac{1}{2}\left(A_b + B_b\right) - \left(\beta - \frac{1}{2}\right)\underline{A}_b + \left(\alpha - \frac{1}{2}\right)\underline{B}_b = 1. \tag{5}$$

Since the investments are relationship-specific, one will expect there will be underinvestment. Proposition 1 verifies this.

Proposition 1 *With 50-50 Nash bargaining between A and B, there is underinvestment under any organization structure $O(\alpha, \beta)$. That is*

$$a^N < a^* \text{ and } b^N < b^* \text{ for all } \alpha, \beta \in [0, 1].$$

Proof. It suffices to verify $a^N < a^*$ since the argument for $b^N < b^*$ is similar. By the assumption that A_{aa} and $B_{aa} < 0$, we know that the A's marginal benefits both in (1) and (4) are decreasing functions of a and hence whichever situation gives A higher marginal benefit will induce higher investment from her. In addition, $\underline{A} = \phi A$ and $\underline{B} = \phi B$ imply that

$$\frac{1}{2}\left[A_a + B_a\right] + \left(\alpha - \frac{1}{2}\right)\underline{A}_a - \left(\beta - \frac{1}{2}\right)\underline{B}_a < A_a + B_a$$

So, we have

$$a^N < a^*.$$

$\blacksquare$

Since relationship specificity of investment is the source of underinvestment problem, one will expect the *degree* of relationship specificity will affect equilibrium investments . Following the spirit of Chiu [2], we define what we mean by saying that one organization structure makes one investor's investment less (more) relationship-specific.

Definition 2 *$O(\alpha, \beta)$ makes A's (B's) investment less relationship-specific than $O(\alpha', \beta')$ does if $\alpha' \underline{A}_a + (1-\beta') \underline{B}_a < \alpha \underline{A}_a + (1-\beta) \underline{B}_a$ (if $(1-\alpha') \underline{A}_b + \beta' \underline{B}_b < (1-\alpha) \underline{A}_b + \beta \underline{B}_b$). Conversely,$O(\alpha, \beta)$ makes A's (B's) investment more relationship-specific than $O(\alpha', \beta')$ does if $\alpha' \underline{A}_a + (1-\beta') \underline{B}_a > \alpha \underline{A}_a + (1-\beta) \underline{B}_a$ (if $(1-\alpha') \underline{A}_b + \beta' \underline{B}_b > (1-\alpha) \underline{A}_b + \beta \underline{B}_b$).*

In Definition 2, the degree of relationship specificity is defined in terms of each investment's marginal return in outside options. Since the marginal returns of a under $O(\alpha, \beta)$ and $O(\alpha', \beta')$ are both decreasing functions of a, if $O(\alpha, \beta)$ makes an investor's investment less (more) relationship-specific than $O(\alpha', \beta')$ does, then $O(\alpha, \beta)$ induces higher (lower) investment from this investor than $O(\alpha', \beta')$ does. This observation gives us the following partial ordering of organization structures.

Proposition 2 *If $O(\alpha, \beta)$ makes both A and B's investments less (more) relationship-specific than $O(\alpha', \beta')$ does, then $O(\alpha, \beta)$ is more (less) efficient than $O(\alpha', \beta')$.*

Since we have a continuum of organization structures to consider, it is useful to categorize them and obtain some comparative statics with this categorization. The following definition offers a way to measure the degree of separation (integration) of an organization structure.

Definition 3 *$O(\alpha', \beta')$ is more separated than $O(\alpha, \beta)$ if $\alpha' > \alpha$ and $\beta' > \beta$. Conversely, $O(\alpha', \beta')$ is more integrated than $O(\alpha, \beta)$ if $\alpha' < \alpha$ and $\beta' < \beta$.*

In addition, the degree of externality matters, too. Definition 4 categorizes two different levels of externality: When the marginal benefit of one investor's investment to the other investor is lower than that to himself, the externality is relatively small; otherwise, the externality is relatively big.

Definition 4 *A's (B's) investment is more productive in her own outside option if* $\underline{A}_a > \underline{B}_a$ *(*$\underline{B}_b > \underline{A}_b$*). A's (B's) investment is less productive in her own outside option if* $\underline{A}_a < \underline{B}_a$ *(*$\underline{B}_b < \underline{A}_b$*).*

Proposition 3 is one of the main results of this paper that provides a link between externalities with the boundaries of the firms.

Proposition 3 *If* $O(\alpha', \beta')$ *is more separated than* $O(\alpha, \beta)$*, then we have*

(a) $O(\alpha, \beta)$ *can not induce higher investments from both A and B if both investors' investments are* ***more*** *productive in their own outside option (externalities are small). In particular,* $O(\alpha', \beta')$ *can induce higher investments from both A and B and hence is more efficient if externalities (*$\underline{A}_b$ *and* $\underline{B}_a$*) are small enough.*

(b) $O(\alpha, \beta)$ *can induce higher investments from both A and B and hence is more efficient if both investors' investments are* ***less*** *productive in their own outside option (externalities are big) and* $\alpha' - \alpha \leq \beta' - \beta$ *or if externalities (*$\underline{A}_b$ *and* $\underline{B}_a$*) are big enough.*

Proof. (a) Given the hypothesis, if $O(\alpha, \beta)$ can induce higher investment from A, then

$$\begin{aligned} \alpha' \underline{A}_a + (1 - \beta') \underline{B}_a &< \alpha \underline{A}_a + (1 - \beta) \underline{B}_a \text{ or} \\ (\alpha' - \alpha) \underline{A}_a &< (\beta' - \beta) \underline{B}_a. \end{aligned}$$

This implies that $(\alpha' - \alpha) < (\beta' - \beta)$ when $\underline{A}_a > \underline{B}_a$. Furthermore, if $O(\alpha, \beta)$ can induce higher investment from B, then

$$(1 - \alpha')\,\underline{A}_b + \beta' \underline{B}_b < (1 - \alpha)\,\underline{A}_b + \beta \underline{B}_b$$

or

$$(\alpha' - \alpha)\,\underline{A}_b > (\beta' - \beta)\,\underline{B}_b,$$

which contradicts with the hypothesis that $\underline{B}_b > \underline{A}_b$. In particular when $\underline{A}_b$ and $\underline{B}_a$ are small enough relatively to $\underline{A}_a$ and $\underline{B}_b$, respectively, since $\alpha < \alpha'$ and $\beta < \beta'$, we can have $(\alpha' - \alpha)\,\underline{A}_a > (\beta' - \beta)\,\underline{B}_a$ and $(\beta' - \beta)\,\underline{B}_b > (\alpha' - \alpha)\,\underline{A}_b$ which implies that $a(\alpha, \beta) < a(\alpha', \beta')$ and $b(\alpha, \beta) < b(\alpha', \beta')$.

(b) If $\underline{A}_a < \underline{B}_a$, $\underline{B}_b < \underline{A}_b$ and $\alpha' - \alpha \leq \beta' - \beta$ or $\underline{A}_b$ and $\underline{B}_a$ are big enough, we have

$$\begin{aligned}
\alpha' \underline{A}_a + (1 - \beta')\,\underline{B}_a &< \alpha \underline{A}_a + (1 - \beta)\,\underline{B}_a \text{ and} \\
(1 - \alpha')\,\underline{A}_b + \beta' \underline{B}_b &< (1 - \alpha)\,\underline{A}_b + \beta \underline{B}_b,
\end{aligned}$$

which implies that $a(\alpha, \beta) > a(\alpha', \beta')$ and $b(\alpha, \beta) > b(\alpha', \beta')$. ■

Proposition 3 verifies the received wisdom: higher externalities between firms favors the integration of them. Intuitively, there are two factors at work in the model: hold-up problem and investment externality. The former causes underinvestment under all organization structures, and the latter (somewhat surprisingly) serves as a remedy to the underinvestment problem and this remedy is better utilized under integration. Integration works best when the there is a strong remedy to work with.

The way investment serves as a remedy to the underinvestment problem can understood as the follows. What integration practically does in this paper is swapping outside options. It could benefits one party but will certainly hurt the other party, too, if the total revenue is fixed. However, here the total revenue is a function of the two parties' investments and hence is not fixed. When one party's investment is less productive in the other's outside option, swapping hurts the former party's investment incentives. However, when one party's investment is more productive in the other's outside option, swapping enhance the former party's investment incentives.

Theoretically speaking, it will be also interesting to characterize the set of investment implementable by altering the boundaries of the firm. Proposition 4 provide this straight forward result.

Proposition 4 *If*

$$\alpha(a,b) = \frac{-\underline{A}_b X + \underline{B}_a Y}{-\underline{A}_a \underline{A}_b + \underline{B}_b \underline{B}_a} \in [0,1]$$

and

$$\beta(a,b) = \frac{\underline{A}_a Y - \underline{B}_b X}{-\underline{A}_a \underline{A}_b + \underline{B}_b \underline{B}_a} \in [0,1]$$

, where $X = 1 - \frac{1}{2}(A_a + B_a) - \frac{1}{2}(\underline{B}_a - \underline{A}_a)$ *and* $Y = 1 - \frac{1}{2}(A_b + B_b) + \frac{1}{2}(\underline{B}_b - \underline{A}_b)$*, then* a *and* b *are implementable under* $O(\alpha(a,b), \beta(a,b))$*.*

Proof. This is obtained by solving the first order conditions ((4) and (5)) for α and β. ■

Note that, from the previous analysis, the first best investment (a^*, b^*) does not belong to this set.

2.2.1 Optimal Organization Structure

In this subsection, we treat organization structures as decision variables and see how should the boundaries of the firm be set optimally. The optimal organization structure $O(\alpha^*, \beta^*)$ satisfies that

$$(\alpha^*, \beta^*) = \arg\max_{(\alpha,\beta)} A(a,b) + B(a,b) - a - b \tag{6}$$

subject to equation (4), (5), and

$$\begin{aligned} \alpha &\leq 1 & (7) \\ \beta &\leq 1 & (8) \end{aligned}$$

By solving the solution $a(\alpha,\beta)$ and $b(\alpha,\beta)$ from (4) and (5) and plugging them into the objective function (4,) we can write the Lagrangian function as

$$L\left(\alpha, \beta, \lambda^\alpha, \lambda^\beta\right) = A(a,b) + B(a,b) - a - b + \lambda^\alpha (1-\alpha) + \lambda^\beta (1-\beta) \ ,$$

where λ^α and λ^β are the multiplier for equation (7) and (8) respectively. If $\alpha > 0$ and $\beta > 0$, the Kuhk-Tucker conditions imply

$$\begin{aligned} \lambda^\alpha &= (A_a + B_a - 1)\frac{\partial a}{\partial \alpha} + (A_b + B_b - 1)\frac{\partial b}{\partial \alpha} & (9) \\ \lambda^\beta &= (A_a + B_a - 1)\frac{\partial a}{\partial \beta} + (A_b + B_b - 1)\frac{\partial b}{\partial \beta} & (10) \end{aligned}$$

, where $\frac{\partial a}{\partial \alpha}$, $\frac{\partial b}{\partial \alpha}$, $\frac{\partial a}{\partial \beta}$, and $\frac{\partial b}{\partial \beta}$ can be obtained by applying the Implicit-Function Theorem to (4) and (5.) Also when $\lambda^\alpha > 0$ and $\lambda^\beta > 0$, the Kuhk-Tucker conditions imply that $\alpha^* = \beta^* = 1$, which means full separation is optimal. Conversely, if some form of integration is optimal ($\alpha^* < 1$ or $\beta^* < 1$,) it must be that $\lambda^\alpha = 0$ or $\lambda^\beta = 0$. We label this result as Proposition [5].

Proposition 5 *If*

$$(A_a + B_a - 1)\frac{\partial a}{\partial \alpha} + (A_b + B_b - 1)\frac{\partial b}{\partial \alpha} > 0 \textit{ and } (A_a + B_a - 1)\frac{\partial a}{\partial \beta} + (A_b + B_b - 1)\frac{\partial b}{\partial \beta} > 0$$

, full separation is optimal.

Note that from Proposition 1, we know that $A_a + B_a - 1 > 0$ and $A_b + B_b - 1 > 0$

2.3 Alternating-offers bargaining

Now assume that A and B bargain under the alternating-offers bargaining structure (as adopted by Chiu [2] and De Meza and Lockwood [8].) Consider $O(\alpha, \beta)$, where $\alpha \in [0,1]$ and $\beta \in [0,1]$. Under the current bargaining structure, A investor's reservation value will not matter unless his/her individual rationality constraint binds. We follow the procedure of De Meza and Lockwood [8] and partition the space of feasible investment $\mathcal{A} \times \mathcal{B}$ into following three regions,

$$\begin{aligned}
R_0(\alpha,\beta) &= \left\{a, b | \frac{1}{2}[A+B] \geq \alpha \underline{A} + (1-\beta)\underline{B}, (1-\alpha)\underline{A} + \beta \underline{B}\right\}, \\
R_A(\alpha,\beta) &= \left\{a, b | \alpha \underline{A} + (1-\beta)\underline{B} > \frac{1}{2}[A+B] \geq (1-\alpha)\underline{A} + \beta \underline{B}\right\}, \text{ and} \\
R_B(\alpha,\beta) &= \left\{a, b | (1-\alpha)\underline{A} + \beta \underline{B} > \frac{1}{2}[A+B] \geq \alpha \underline{A} + (1-\beta)\underline{B}\right\}.
\end{aligned}$$

[5] $|J|$ is positive when $A_{aa} < A_{ab} = A_{ba} < 0$, $A_{bb} < A_{ab} = A_{ba} < 0$, $B_{aa} < B_{ab} = B_{ba} < 0$, $B_{bb} < B_{ab} = B_{ba} < 0$. When $A_{ab} > 0$ and $B_{ab} > 0$, then $\frac{\partial a}{\partial \alpha}, \frac{\partial b}{\partial \alpha} > 0$ and $\frac{\partial a}{\partial \beta}, \frac{\partial b}{\partial \beta} < 0$. It seems that (9) and (10) will not hold. But then the sign of $|J|$ is not necessary positive. So (9) and (10) are fine

In $R_0(\alpha,\beta)$, none of A and B's individual rationality constraint binds. In $R_A(\alpha,\beta)$, A's individual rationality constraint binds but B's does not. In $R_B(\alpha,\beta)$, B's individual rationality constraint binds but A's does not. A and B's payoffs now are respectively

$$-a+\begin{cases}\frac{1}{2}[A+B] & \text{if } (a,b)\in R_0(\alpha,\beta)\\ \alpha\underline{A}+(1-\beta)\underline{B} & \text{if } (a,b)\in R_A(\alpha,\beta)\\ A+B-((1-\alpha)\underline{A}+\beta\underline{B}) & \text{if } (a,b)\in R_B(\alpha,\beta)\end{cases}, \text{ and}$$

$$-b+\begin{cases}\frac{1}{2}[A+B] & \text{if } (a,b)\in R_0(\alpha,\beta)\\ A+B-(\alpha\underline{A}+(1-\beta)\underline{B}) & \text{if } (a,b)\in R_A(\alpha,\beta)\\ (1-\alpha)\underline{A}+\beta\underline{B} & \text{if } (a,b)\in R_B(\alpha,\beta)\end{cases}$$

Without loss of generality we assume that B's outside option never binds so we can ignore the case of $(a,b)\in R_B(\alpha,\beta)$ and the pure strategy Nash equilibrium can be one of the following two possibilities: $(a_0,b_0)\in R_0(\alpha,\beta)$ and $(a_A,b_A)\in R_A(\alpha,\beta)$. It is straight forward to see that

$$\begin{aligned}a_0 &= \arg\max_a \frac{1}{2}[A+B]-a,\\ b_0 &= \arg\max_b \frac{1}{2}[A+B]-b,\\ a_A &= \arg\max_a \alpha\underline{A}+(1-\beta)\underline{B}-a, \text{ and}\\ b_A &= \arg\max_a A+B-\alpha\underline{A}-(1-\beta)\underline{B}-b.\end{aligned}$$

The boundary between $R_0(\alpha,\beta)$ and $R_A(\alpha,\beta)$ is determined by the following equation:

$$\frac{1}{2}[A(a,b)+B(a,b)]-\alpha\underline{A}-(1-\beta)\underline{B}=0. \tag{11}$$

By applying the implicit-function theorem to (11), we have

$$\frac{db}{da} = -\frac{\frac{1}{2}[A_a + B_a] - \alpha \underline{A}_a - (1-\beta)\underline{B}_a}{\frac{1}{2}[A_b + B_b] - \alpha \underline{A}_b - (1-\beta)\underline{B}_b} \tag{12}$$

For simplicity, we will make the following assumption.

Assumption: $\frac{db}{da} < 0$.[6]

Under this assumption, the boundary between set R_0^I and R_A^I is downward sloping. Note we can rewrite (12) as

$$\frac{db}{da} = -\frac{MB^{A0} - MB^{AA}}{MB^{BA} - MB^{B0}}$$

where $MB^{A0} = \frac{1}{2}[A_a + B_a]$ is the marginal benefit of A's investment when A's outside option is not binding, $MB^{AA} = \alpha \underline{A}_a + (1-\beta)\underline{B}_a$ is the marginal benefit of A's investment when A's outside option is binding, $MB^{B0} = \frac{1}{2}[A_a + B_a]$ is the marginal benefit of B's investment when A's outside option is not binding, $MB^{BA} = [A_b + B_b] - \alpha \underline{A}_b - (1-\beta)\underline{B}_b$ is the marginal benefit of B's investment when A's outside option is binding. In the following analysis, we focus on pure-strategy Nash Equilibrium in the following two instructive cases:[7]

Case 1: $MB^{A0} - MB^{AA} > 0$ and $MB^{BA} - MB^{B0} > 0$ for all $\alpha, \beta \in [0,1]$.

Case 2: $MB^{A0} - MB^{AA} < 0$ and $MB^{BA} - MB^{B0} < 0$ for all $\alpha, \beta \in [0,1]$.

It is easy to see that $b_A > b_0$ (since $MB^{BA} > MB^{B0}$) and $a_0 > a_A$ (since $MB^{A0} > MB^{AA}$) in Case 1 and that $b_A < b_0$ (since $MB^{BA} < MB^{B0}$) and $a_0 < a_A$ (since $MB^{A0} < MB^{AA}$) in Case 2. We label this result as Lemma 1.

[6] This assumption holds whenever $\frac{1}{2} > \phi$ and entails the same effect as the assumption 4 of De Meza and Lockwood [8].

[7] We ignore any mixed-strategy Nash equilibrium since it does not entails any qualititative change in the results.

Lemma 1 *In Case 1, the binding of A's outside option will decrease A's investment and increase B's investment. In Case 2, the binding of A's outside option will increase A's investment and decrease B's investment.*

Chiu [2] and De Meza and Lockwood [8] point out that ownership might be bad for investment incentives. Proposition is analogous to this result because it says that outside recognition can causes a employee's outside option to bind and decrease his/her investment.

Proposition 1 of the previous section shows that there is always underinvestment regardless the ownership structure when A and B bargain under Nash bargaining structure. This is due to the hold-up problem, and changing the bargaining structure to alternating-offer bargaining should not change this qualitatively. Proposition 6 verifies this.

Proposition 6 *If A and B bargain with alternating-offers bargaining structure, there is under-investment under any organization structure $O(\alpha, \beta)$. That is if a^T and b^T are the equilibrium investment levels when A and B bargain with alternating-offers bargaining structure, then*

$$a^T < a^* \text{ and } b^T < b^* \text{ for all } \alpha, \beta \in [0, 1].$$

Proof. From Lemma 1 we know that the highest investment of A is a_0 in Case 1 and a_A in Case 2. The fact that $a^T < a^*$ can be obtained by an argument similar to Proposition 1's proof. The proof of $b^T < b^*$ is analogous. ■

In comparing any change of organization structure, one of the major concern is whether the change will cause an investor's (A's) outside option to bind which will cause a discrete jump or fall in the investor's investment. To be more specific, for any two organization structures $O(\alpha, \beta)$

and $O(\alpha', \beta')$ if A's outside option is binding under $O(\alpha', \beta')$ but not under $O(\alpha, \beta)$, then we know from Lemma 1 that $O(\alpha', \beta')$ induce higher investment from A and lower investment from B in Case 1 and induce lower investment from A and higher investment from B in Case 2.

If A's outside option is binding under both $O(\alpha, \beta)$ and $O(\alpha', \beta')$, then A's payoff is $\alpha\underline{A} + (1-\beta)\underline{B} - a$ and B's payoff is $A + B - (\alpha\underline{A} + (1-\beta)\underline{B}) - b$. In this case, $O(\alpha, \beta)$ induce higher investment from A than $O(\alpha', \beta')$ does if and only if $\alpha\underline{A}_a + (1-\beta)\underline{B}_a > \alpha'\underline{A}_a + (1-\beta')\underline{B}_a$, $O(\alpha, \beta)$ can induce higher investment from B than $O(\alpha', \beta')$ does if and only if $\alpha\underline{A}_b + (1-\beta)\underline{B}_b > \alpha'\underline{A}_b + (1-\beta')\underline{B}_b$.

If A's outside option is not binding under either $O(\alpha, \beta)$ or $O(\alpha', \beta')$, then A's payoff is $\frac{1}{2}[A+B] - a$ and B's payoff is $\frac{1}{2}[A+B] - b$. In this case, the boundaries of the firm does not matter since α and β do not enter either A or B's payoff function. Proposition summarizes the above results.

Proposition 7 *Given any two organization structures $O(\alpha, \beta)$ and $O(\alpha', \beta')$,*

- *If A's outside option is binding under $O(\alpha', \beta')$ but not under $O(\alpha, \beta)$, then $O(\alpha, \beta)$ induces higher investment from A and lower investment from B than $O(\alpha', \beta')$ does in Case 1, and $O(\alpha, \beta)$ induces lower investment from A and higher investment from B than $O(\alpha', \beta')$ does in Case 2.*

- *If A's outside option is binding under both $O(\alpha, \beta)$ and $O(\alpha', \beta')$, then $O(\alpha, \beta)$ induce higher investment from A than $O(\alpha', \beta')$ does if and only if $\alpha\underline{A}_a + (1-\beta)\underline{B}_a > \alpha'\underline{A}_a + (1-\beta')\underline{B}_a$, $O(\alpha, \beta)$ can induce higher investment from B than $O(\alpha', \beta')$ does if and only if $\alpha\underline{A}_b + (1-\beta)\underline{B}_b > \alpha'\underline{A}_b + (1-\beta')\underline{B}_b$.*

- *If A's outside option is binding under neither $O(\alpha, \beta)$ nor $O(\alpha', \beta')$, then boundaries of the firms does not matter.*

3 Relational Contracts

In the previous two sections, we assume that neither the outputs (A and B) nor the investments (a and b) are contractible, in the sense that they can not be verified by a court. However, in a repeated relationship, a desirable investment level by one party might be enforced by the threat of future punishment from the other party. Baker, Gibbons and Murphy [1] refer to these type of contracts as 'relational contract' and showed that assets ownership matters when the investment game is repeated and parties can sign relational contracts. In this section, we extend their results under the new definition of the firm.

Denote $U^{SA}(a, b, \alpha, \beta) \equiv \alpha \underline{A} + (1-\beta)\underline{B} + \frac{1}{2}\left[A + B - \underline{A} - \underline{B}\right]$ and $U^{SB}(a, b, \alpha, \beta) \equiv (1-\alpha)\underline{A} + \beta \underline{B} + \frac{1}{2}\left[A + B - \underline{A} - \underline{B}\right]$ as the spot (when the investment game is not repeated) gross benefit of A and B, respectively. For any given $O(\alpha, \beta)$, the equilibrium investment levels are a^S and b^Smaximize (2) and (3)[8], i.e.

$$\begin{aligned} a^S(\alpha, \beta) &= \arg\max_a U^{SA}\left(a, b^S, \alpha, \beta\right) - a \text{ and} \\ b^S(\alpha, \beta) &= \arg\max_b U^{SB}\left(a^S, b, \alpha, \beta\right) - b. \end{aligned}$$

Note that we change the superscript here from N to S to represent spot contracts.

When the investment game is repeated, a relational contract can be written on any variables,

[8] Here we ignore the case of alternating-offer bargaining.

in particular the outputs (A and B) and investments (a and b), that are observable to both parties. So we can focus our analysis on any division of the total surplus, i.e. any pair of payoff of A and B $\left\{U^{RA}(a,b), U^{RB}(a,b)\right\}$ that satisfies

$$U^{RA}(a,b) + U^{RB}(a,b) = A(a,b) + B(a,b).$$

This implies that equilibrium investment $\left(a^R, b^R\right)$ must satisfies

$$\begin{aligned} a^R &= \arg\max_a U^{RA}\left(a, b^R\right) - a \text{ and} \\ b^R &= \arg\max_b U^{RB}\left(a^R, b\right) - b. \end{aligned}$$

Note that $U^{RA}(a,b)$ and $U^{RB}(a,b)$ are a prior independent of how the boundaries of the firm is set up.

In accordance with Baker, Gibbons and Murphy [1], we assume that after renege, the two parties lives under spot governance with the optimal ownership structure $O(\alpha^*, \beta^*)$, defined in section 2.2.1,forever, which gives A and B $U^{SA}\left(a^S(\alpha^*,\beta^*), b^S(\alpha^*,\beta^*), \alpha^*, \beta^*\right) \equiv U^{SA*}$ and $U^{SB}\left(a^S(\alpha^*,\beta^*), b^S(\alpha^*,\beta^*), \alpha^*, \beta^*\right) \equiv U^{SB*}$, respectively. As a result, the condition for A to honor the relational contract is

$$U^{RA}\left(a^R, b^R\right) + \frac{1}{r}U^{RA}\left(a^R, b^R\right) \geq \max_a U^{SA}\left(a, b^R, \alpha, \beta\right) + \frac{1}{r}U^{SA*} \tag{13}$$

The condition for B to honor the relational contract is

$$U^{RB}\left(a^R,b^R\right)+\frac{1}{r}U^{RB}\left(a^R,b^R\right)\geq\max_b U^{SB}\left(a^R,b,\alpha,\beta\right)+\frac{1}{r}U^{SB*} \tag{14}$$

Summing the two yields

$$\begin{aligned}&\frac{1}{r}\left[U^{RA}\left(a^R,b^R\right)-U^{SA*}+U^{RB}\left(a^R,b^R\right)-U^{SB*}\right] \qquad (15)\\ \geq\ &\max_a U^{SA}\left(a,b^R,\alpha,\beta\right)-U^{RA}\left(a^R,b^R\right)+\max_b U^{SB}\left(a^R,b,\alpha,\beta\right)-U^{RB}\left(a^R,b^R\right).\end{aligned}$$

where the LHS is the net present value of the total future punishment if some party reneges and the RHS is the total temptation to renege. Since for any relational contract $\left(U^{RA},U^{RB}\right)$ that satisfies (15) there exist a $t\in\mathbf{R}$ such that the relational contract $\left(U^{RA\prime},U^{RB\prime}\right)=\left(U^{RA}-t,U^{RB}+t\right)$ satisfies both (13) and (14), it is without loss of generality to focus on (15) as a necessary and sufficient condition for a relational contract to be feasible.

The major results of Baker, Gibbons and Murphy [1] are that (i) asset ownership will affect the feasibility of relational contracts and (ii) the ability to use relational contract does not implies one ownership structure (say integration) always dominates another (say non-integration.) In this section two analogous results are obtained under the new definition of the firm.

First, by examining (15) we know that organization structure affect the total temptation to renege which in turn determines the feasibility of a relational contract. This straightforward result is analogous to (i) and labeled as Proposition 8.

Proposition 8 *Whether a given relational contract is feasible depends on the underlying organization structure.*

To see that relational contracts can not mimic spot bargaining, consider implementing $a^S(\alpha,\beta)$ and $b^S(\alpha,\beta)$ under $O(\alpha',\beta')$ where $\alpha \neq \alpha'$ or $\beta \neq \beta'$. The only way to do this is to set $U^{RA}(a,b) = U^{SA}\left(a^S(\alpha,\beta), b^S(\alpha,\beta), \alpha, \beta\right)$ and $U^{RB}(a,b) = U^{SB}\left(a^S(\alpha,\beta), b^S(\alpha,\beta), \alpha, \beta\right)$. The punishment to renege is negative since the LHS of (15) is

$$\frac{1}{r}\left[U^{SA}\left(a^S(\alpha,\beta), b^S(\alpha,\beta), \alpha, \beta\right) - U^{SA*} + U^{SB}\left(a^S(\alpha,\beta), b^S(\alpha,\beta), \alpha, \beta\right) - U^{SB*}\right] < 0.$$

The temptation to renege is positive since the RHS of (15) is

$$\begin{aligned} &\max_a U^{SA}\left(a, b^S(\alpha,\beta), \alpha, \beta\right) - U^{SA}\left(a^S(\alpha,\beta), b^S(\alpha,\beta), \alpha, \beta\right) \\ &+ \max_b U^{SB}\left(a^S(\alpha,\beta), b, \alpha, \beta\right) - U^{SA}\left(a^S(\alpha,\beta), b^S(\alpha,\beta), \alpha, \beta\right) \end{aligned}$$

which is nonnegative. So (15) will not hold. This result is summarized in Corollary 1.

Corollary 1 *Spot bargaining under one organization structure can not be mimiced by relational contracts under another organization structure. Technically, if $\alpha \neq \alpha'$ or $\beta \neq \beta'$ then $a^*(\alpha,\beta)$ and $b^*(\alpha,\beta)$ can not be equilibrium under $O(\alpha',\beta')$ even when relational contracts is allowed.*

4 Conclusion

By introducing a new definition of the firm, we extend the framework of the property-rights approach to the theory of the firm to establish a new theory that puts people at the center of the firm. The new definition totally ignore tangible, physical assets and view people who work in close relationship so that external market can not distinguish them individually as a firm.

This new definition explain the merger of human-capital intensive firms such as professional service firms. We also rediscover the role of externalities in determining boundaries of the firms. While we use human-capital intensive firms to motivate, the result of this paper also apply to physical-capital intensive firms, too. The firms defined in the paper may look different from legally defined firms. This is because it is difficult to define in terms of intangible items such as outside identification addressed in this paper. We believe the new definition captures new aspects of the firm. We hope the simplicity of the model makes it easier to extend to future works. One important issue that is not addressed in the current paper is what happens when people compete for outside identification. We hope to analyze this question in future research.

References

[1] G. Baker, R. Gibbons, K.J. Murphy, Relational Contracts and the Theory of the Firm, *Quarterly Journal of Economics*, **117** 1, 2002, 39-84.

[2] Y.S. Chiu, Noncooperative Bargaining, Hostages, and Optimal Asset Ownership, *American Economic Review*, **88** 4, 1998, 882-901.

[3] M. Engers, J. S. Gans, S. Grant, and S. P. King, First-Author Conditions, *Journal of Political Economy*, **107** 4 1999, 859-83.

[4] S. Grossman and O. Hart, The Costs and Benefits of Ownership: A Theory of Vertical and Lateral Integration, *Journal of Political Economy*, **94** 1986, 691-719.

[5] O. Hart and J. Moore, Property Rights and the Nature of the Firm, *Journal of Political Economy*, **98** 1990, 1119-58.

[6] B. Holmstrom, The Firm as a Subeconomy, *Journal of Law, Economics, & Organization*, **15** 1999, 74-102.

[7] J. Levin and S. Tadelis, A Theory of Partnerships, mimeo, Stanford University, 2002.

[8] D. De Meza and B. Lockwood, Does Asset Ownership Always Motivate Managers? Outside Options and the Property Rights Theory of the Firm, *Quarterly Journal of Economics*, **113** 2, 1998, 361-86.

[9] R. Rajan and L. Zingales, Power in a theory of the firm, *Quarterly Journal of Economics*, **113** 2, 1998, 387-432.

[10] R. Rajan and L. Zingales, The Firm As A Dedicated Hierarchy: A Theory Of The Origins And Growth Of Firms, *Quarterly Journal of Economics*, **116** 3, 2001, 805-851.

[11] L. Zingales, In Search of New Foundations, *Journal of Finance*, **55** 2000, 1623-53.