The Boundaries of the Firms as Information Barriers*

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Abstract

Most existing theories of the firms define a firm as a collection of physical assets, and hence can not explain the firm from a human-asset perspective, which is of particular importance for understanding human-capital intensive firms. To fill in the gap, this paper proposes an alternative definition – a firm is a group of people who work in a very close way so that outsiders cannot

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clearly distinguish one group member from another. By this definition, the boundaries of the firm matter because they can alter investment specificity 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 externalities are small. This result is obtained under both Nash and alternating-offer bargaining. The effect of ‘relational contracts’ (Baker, Gibbons and Murphy [1]) is also examined to show that the newly defined organization structures matter even when relational contracts can be signed.

1 Introduction

What difference does it make when firms merge? This question has been extensively studied in economics – from the traditional undergraduate microeconomics that argues mergers can internalize externalities, to the modern property rights approach that argues when one firm acquires another the former enjoys a better bargaining position and hence is more willing to make relationship-specific investment. However, in most of these theories the firms are defined as collections of physical assets, and people are often left out of the picture. As a result, they cannot consider firms from a human perspective, which is particularly important in understanding human-capital intensive firms, such as law, consulting, medicine, investment banking, advertising and accounting firms, that are playing an increasingly important role in most economies. This problem has been recently pointed out by Zingales [14], and some studies have been devised to address it. For example Rajan and Zingales [11] and [12] define a firm as a set of unique assets and a group of people who have access to those assets. However, these studies do not focus on explaining the boundaries of the firms, and hence the question of why firms – *defined as collections of human assets* – merge or separate is left unanswered. This paper will propose a preliminary step in this direction.

The main idea is based on the following observation – when firms merge, their individual values become less clearly observed from the outside of the integrated firm. One reason, among many others, for this could be that after firms merge a common name is normally used to represent both of them and integrated financial reports are issued instead of separated reports. Alternatively, it could be because firms intentionally blur employees' individual identities to promote team work and discourage individualism. An example, which is not directly related to industrial mergers but to institutions in general, is that many joint research papers in economics are published with the authors' names listed in alphabetical order, instead of ranked by contributions, so that individual contributions are harder to assess (Engers et al.

[5].)

As a result of the observation, external markets are forced to make an estimation if they want to know the value of a particular segment of a firm. This estimation will be based on the markets' belief about how different components of the total value of the firm should be attributed to the segment. For example, if a certain segment of IBM is believed to be responsible for its hardware maintenance service, then the failure or success of this service will be mostly attributed to that segment. However, what is important is that because this segment belongs to a firm that contains other segments, and the individual identities of those segments cannot be clearly observed, the true value of each segment will be, to some extent, misattributed to others by the external market. Consequently, the markets' estimation of the value of any particular segment of a firm will depend on the true values of all segments in the firm.

This type of 'identity mixing' can be easily observed in the real world. For example, employers, for lack of better information, often evaluate job candidates by looking at the performance of the firms for which they use to work. In fact, a candidate from a successful firm (e.g.,, General Electric) is often considered to be of higher quality than a candidate from a firm that is in trouble (e.g., Author Anderson after the Enron scandal) regardless of the real qualities of the candidates. In addition to individual workers, the identify of a segment of a firm is often affected by the rest of the firm. For example, Electronic Data Systems, an information-technology consultancy, is recognized as having expertise in the automotive industry because it used to belong to General Motors. After Electronic Data Systems was separated from General Motors, this recognition helped it to win a 10 year extensive contract with Rolls-Royce in 1995. Although one might argue that judging workers by the firm they work for, or business segments by the firms they belong, can give one a decent picture of their true value, the important thing is that the picture is rarely 100% clear and, more interestingly, in many cases the picture is very vague.

Based on the above discussion, we can define a firm as *a group of people who work together in a close way such that outsiders can only identify with the firm as a whole and not with individual employees.* Hence, the boundaries of the firms can be viewed as 'information garbling' devices that blur employees' individual outside identities. By this definition, we find that integration is more efficient when investment externalities are high (for example, when the value of one person's human capital increases rapidly with another person's effort) and less efficient when investment externalities are low. This result can be obtained under both Nash (as in Grossman and Hart [6] and Hart and Moore [7]) and alternating-offer (as in Chiu [3] and De Meza and Lockwood [10]) bargaining, two leading bargaining structures used in the literature. In the latter part of the paper, the investment game will be allowed to be repeated so that parties can sign 'relational contracts' as defined by Baker, Gibbons and Murphy [1]. Hence, the influence of the newly defined organization structure on the feasibility of relational contracts can be examined.

To illustrate the intuition, consider one of the most significant recent mergers in consulting industry – that between IBM and PricewaterhouseCoopers' consulting practice (henceforth PwC). It is believed that this merger will help IBM, the major revenues of which come from selling and maintaining hardware, to reinvent itself as an expert in high-end business strategy – an image that PwC currently enjoys. We will use the following hypothetical scenario to explain the idea of the paper. Suppose that a project requires a new business strategy (potentially from PwC) and a new computer system (potentially from IBM) to implement the strategy. IBM's investment could have positive externalities (spillovers) to the value of PwC's strategy: that is, the value of PwC's strategy can be increasing in IBM's investment. For example, IBM's investment in designing a test-run system might identify potential problems in PwC's strategy and help PwC to fix them. In addition, any value that is added to PwC's strategy can be realized even though the strategy is implemented with a system that is provided by a firm other than IBM. This means that IBM's investment can also have positive externalities to PwC's *outside option*. Continuing with the example, even if PwC eventually decide to implement its strategy with a system that is designed by a firm other than IBM, Pwc's enhanced strategy still benefit from IBM's investment early on because it is free from the identified potential problems.

If PwC and IBM are two separated firms, then this enhanced outside option accrues only to PwC, because the market knows clearly that PwC is responsible for strategy. However, if PwC and IBM were two segments of one integrated firm called, say, X, the market will not be clear about who is responsible for the strategy. In this case, IBM might be able to capture some of PwC's enhanced outside option, because if it were to be separated from PwC, people might think that it had more expertise in strategy than it actually did and hence will be willing to pay more for its services. This additional outside option enhances IBM's bargaining position with PwC, and provides additional incentives for IBM to invest.

With the well-known holdup problem and the resulting underinvestment in the background, integration will improve efficiency when the externalities are large because integration can then induce much more investment from IBM without forgoing too much investment from PwC for losing some of its outside option to IBM. Conversely, when the externalities are small, integration can be suboptimal. One example of the latter case is the recent collaboration of IBM and KPMG on a product to enhance financial reporting. IBM and KPMG might work as independent firms because there is no substantial investment externalities between them, and hence the benefit of giving one the other's outside option is not enough to cover its cost.

In the related literature, the property rights approach pioneered by Grossman and Hart [6] and Hart and Moore [7] is one of the most prominent theories of the firms. The general theme of this approach is that, when contracts are incomplete, the ownership of physical assets matters because it can alter the marginal return on investment and hence change the investors' incentives to invest[1]. As argued above, this physical-asset perspective loses sight of the human aspects of firms.

Levin and Tadelis [9] studied human-capital intensive firms and built a theory of partnerships, but did not focus on the boundaries of the firms. The comparison between partnership and our idea of the firms is that partnership is usually defined as an institution that redistributes *profits* among partners, whereas the firm is an institution that redistributes *outside options* among members of the firm. This model is similar to some of the recent studies on reputation (for example Tadelis[13]) because it also entertains the idea that outside identity can be transferable, although the definition of outside identity is rather different here. Moreover, the idea that garbling information can improve efficiency can be found in the literature on career

[1] Under the Nash bargaining structure of Grossman and Hart[6] and Hart and Moore[7], ownership can enhance a manager's investment incentives. Under the alternating-offers bargaining structure of Chiu [3] and De Meza and Lockwood [10], however, ownership can hinder the manager's investment incentives.

concern (for example Dewatripont, Jewitt, and Tirole[4]). Finally, investments with externalities have been studied in various literatures under different names. For example, in the incomplete contract literature they are called cooperative investment by Che and Hausch[2]. Again, very few of these studies deal with the boundaries of the firms, which are the main focus of this paper.

The paper is organized as follows. Section 2 presents a one-shot investment game between two investors and the main results of considering both Nash and alternating-offer bargaining structures. Section 3 extends the one-shot results by repeating the investment game, in the same way that Baker, Gibbons and Murphy [1] extended the results of Grossman and Hart [6] and Hart and Moore [7]. Section 4 concludes the paper.

2 The One-shot (spot) investment game

2.1 Basic setup

Imagine that a project requires collaboration between consultants A and B, which means combining their human capital and solving one problem (but does not mean integration, as discussed latter.) Denote as $a \in \mathbf{R}^+$ and $b \in \mathbf{R}^+$ the investments that consultants A and B make in increasing their human capital. The private marginal costs of the investments are unity for both consultants. Denote the values of consultant A and consultant B's human capital as $A(a,b)$ and $B(a,b)$, respectively. Assume that the total value of the project is the sum of the values of consultant A and consultant B's human capital, that is $A(a,b)+B(a,b)$. Assume also that $A_b > 0$ and $B_a > 0$. This reflects the idea that one person's investment has positive externalities to the other[2]. In addition, assume that the Hessian $D^2F(a,b)$, where $F(a,b) \equiv A(a,b)+B(a,b)-a-b$, is a negative definite symmetric matrix so that first order conditions imply optimality. In the above setting, the first best investment is a pair (a^*,b^*) such that $(a^*,b^*) = \arg\max A+B-a-b$ or

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

$$A_b(a^*,b^*)+B_b(a^*,b^*) = 1. \tag{2}$$

If consultants A and B collaborate and the project is carried out, then a return equal to $A(a,b)+B(a,b)$ will be paid jointly to them. However, if either of them decides to withdraw their human capital and cancel the collaboration, the project will totally fail and generate no value. In that case, each consultant can independently use their individual human capital to trade with an outsider and receive an outside option. Denote the values of consultant A and consultant B's human capital in the

[2] For simplicity, negative spillovers are not considered.

secondary projects as $\underline{A}(a,b)$ and $\underline{B}(a,b)$, respectively. In addition, the investments that consultants A and B make are relationship-specific in the sense that their human capital will be discounted in their respective outside options because these options are less efficient uses of their human capital. In fact, assume that $\underline{A} = \phi A$ and $\underline{B} = \phi B$ where $\phi \in (0,1)$. Note that the setup above allows the investment of one consultant to affect the other's outside option, which is one of the important features of the model.

The other important feature is that the outside market may or may not observe the fact that consultant A owns $A(a,b)$ and consultant B owns $B(a,b)$, depending on whether consultants A and B are separated or integrated. Specifically, we assume that the outside market believes, with probability one, that $\alpha \in [0,1]$ portion of $A(a,b)$ belongs to A (and hence the remaining $1-\alpha$ portion belongs to B) and $\beta \in [0,1]$ portion of $B(a,b)$ belongs to B (and hence the remaining $1-\beta$ portion belongs to A.) This setting allows us to parameterize all of the possible organization structures by the beliefs of external labor markets. Hence the following will discuss an organization structure with parameters (α, β) as $O(\alpha, \beta)$. There will also be a continuum of different types of organization structures, and integration is relatively defined as in the following, which reflects the idea that a higher degree of integration means a greater distortion of individual identities.[3]

Definition 1 *$O(\alpha, \beta)$ is more integrated than $O(\alpha', \beta')$ if $\alpha < \alpha'$ and $\beta < \beta'$.*

Suppose that external labor markets will pay consultants A and B the 'estimated' values of their respective human capital based on their beliefs. This implies that consultant A and consultant B's outside options under $O(\alpha, \beta)$ equal $\alpha \underline{A} + (1 - \beta) \underline{B}$ and $(1 - \alpha) \underline{A} + \beta \underline{B}$ respectively. Hence, the reservation value of any particular employee essentially becomes a mixture of the reservation values of all employees in the firm, with weightings depending the parameters of the boundaries of the firms, i.e. α and β.

Note that *integration and collaboration* mean different things: the former is a special type of organizational arrangement and the latter is a task that needs to be accomplished by organizational arrangement (not necessarily integration.) For example, consultants A and B can collaborate under a totally separated organization structure (that is, when $\alpha = \beta = 1$). Furthermore, consultants A and B know that it is jointly more profitable for them to collaborate, but they need to bargain over the joint return $A(a, b) + B(a, b)$ *after* they invest. This introduces the well-known hold-up problem, and the following two sections analyze this problem under two leading

[3]The definition for separation is symmetric.

bargaining structures used in the literature: *Nash bargaining* and *alternating-offers bargaining*.

2.2 Nash Bargaining

Assume consultants A and B bargain over the total surplus, $A(a,b) + B(a,b)$, in a 50-50 Nash bargaining game where their reservation values equal their respective payoffs in external labor markets. Given organization structure $O(\alpha, \beta)$, consultant A's payoff is

$$F^{NA}(a) \equiv \alpha \underline{A} + (1-\beta)\underline{B} + \frac{1}{2}\left[A + B - \underline{A} - \underline{B}\right] - a \tag{3}$$

and consultant B's payoff is

$$F^{NB}(b) \equiv (1-\alpha)\underline{A} + \beta \underline{B} + \frac{1}{2}\left[A + B - \underline{A} - \underline{B}\right] - b. \tag{4}$$

Here we need to extend our assumptions about second order conditions to include that $A_{aa} < 0$ for all b, B_{bb} for all a so that a Nash equilibrium of this investment game is a pair of investments $\left(a^N, b^N\right)$ that satisfies the following first order conditions:

$$\frac{1}{2}(A_a + B_a) + \left(\alpha - \frac{1}{2}\right)\underline{A}_a - \left(\beta - \frac{1}{2}\right)\underline{B}_a = 1 \tag{5}$$

$$\frac{1}{2}(A_b + B_b) - \left(\beta - \frac{1}{2}\right)\underline{A}_b + \left(\alpha - \frac{1}{2}\right)\underline{B}_b = 1. \tag{6}$$

Because the investments are relationship-specific, one will expect there to be underinvestment. Lemma 1 verifies this.

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

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

Proof. It suffices to show that $a^N < a^*$ because the argument for $b^N < b^*$ is symmetric. By the assumption that A_{aa} and $B_{aa} < 0$, we know consultant A's marginal benefits in (1) and (5) are both decreasing functions of a, and hence whichever situation gives A an higher marginal benefit will induce higher investment from consultant A. In addition, $\underline{A} = \phi A$ and $\underline{B} = \phi B$ imply that

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

Consequently, $a^N < a^*$. ■

By solving (5) and (6) for α and β, we can obtain the characterization of the set of investments that is implementable under an organization structure, which is given in Lemma 2. Note that, from the previous analysis, the first best investment (a^*, b^*) does not belong to this set.

Lemma 2 *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* $O(\alpha(a,b), \beta(a,b))$*.*

Because the relationship specificity of investment is the source of the underinvestment problem, the *degree* of relationship specificity should affect equilibrium investments . Following the spirit of Chiu [3], we can define why one organization structure makes one investor's investment less (more) relationship-specific.

Definition 2 $O(\alpha, \beta)$ *makes consultant A's (consultant 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 consultant A's (consultant 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 its outside option. Because 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 does $O(\alpha', \beta')$, then $O(\alpha, \beta)$ induces higher (lower) investment from this investor than does $O(\alpha', \beta')$. This observation gives us the following partial ordering of organization structures.

Proposition 1 *If $O(\alpha, \beta)$ makes both consultant A and consultant B's investments less (more) relationship-specific than does $O(\alpha', \beta')$, then $O(\alpha, \beta)$ is more (less) efficient than $O(\alpha', \beta')$.*

2.2.1 Externalities Revisited

In reality, externalities certainly play an important role in mergers – the word 'synergy' has been one of the most popular buzzwords used in justifying mergers. From the standard physical-asset perspective, the idea that integration can internalize externalities is very well known. For example, when competing duopolies are integrated and become a monopoly the joint producer surplus increases. The explanation of this standard perspective is rather trivial – integration simply transforms a multi-person game into a single-person decision problem. However, if we view a firm as a group of people instead of assets, it is not entirely clear why integration can internalize externalities, because the problem is always a multi-person game, before or after integration.

In our model, the externalities of investments (in addition to relationship specificity) also play a very important role in determining the optimal organization structure. Definition 3 below 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 3 *Consultant A's (consultant B's) investment is more productive in her (his) own outside option if* $\underline{A}_a > \underline{B}_a$ ($\underline{B}_b > \underline{A}_b$)*. consultant A's (consultant B's) investment is less productive in her (his) own outside option if* $\underline{A}_a < \underline{B}_a$ ($\underline{B}_b < \underline{A}_b$)*.*

Proposition 2 is one of our main results, and provides a link between externalities with the boundaries of the firms from a human-capital perspective.

Proposition 2 *If* $O(\alpha, \beta)$ *is more integrated than* $O(\alpha', \beta')$*, then we have*

(a) $O(\alpha, \beta)$ ***cannot*** *induce higher investments from consultants 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 consultant A and consultant 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 consultant A and consultant 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 $\alpha'\underline{A}_a + (1-\beta')\underline{B}_a < \alpha\underline{A}_a + (1-\beta)\underline{B}_a$ or$(\alpha'-\alpha)\underline{A}_a < (\beta'-\beta)\underline{B}_a$. This implies that $(\alpha'-\alpha) < (\beta'-\beta)$ when $\underline{A}_a > \underline{B}_a$. Similarly, 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 relative to $\underline{A}_a$ and $\underline{B}_b$ respectively, because $\alpha < \alpha'$ 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 $b(\alpha,\beta) < b(\alpha',\beta')$, where $(a(\alpha,\beta), b(\alpha,\beta))$ is the investment pair under $O(\alpha,\beta)$ and $(a(\alpha',\beta'), b(\alpha',\beta'))$ is the investment pair under $O(\alpha',\beta')$.

(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, then we have $\alpha'\underline{A}_a+(1-\beta')\underline{B}_a < \alpha\underline{A}_a+(1-\beta)\underline{B}_a$ and $(1-\alpha')\underline{A}_b+\beta'\underline{B}_b < (1-\alpha)\underline{A}_b+\beta\underline{B}_b$, which implies that $a(\alpha,\beta) > a(\alpha',\beta')$ and $b(\alpha,\beta) > b(\alpha',\beta')$. ■

The intuition of Proposition 2 can be understood as follows. There are two factors at work in the model: a hold-up problem and investment externalities. The former causes underinvestment in all organization structures, and the latter (somewhat surprisingly) serve as remedies to the underinvestment problem that are better utilized under integration. Integration works best when there are strong remedies with which to work.

The way in which investment externalities serve as remedies to the underinvestment problem can be understood as the follows. Essentially, what integration does can be roughly viewed as swapping outside options. It benefits one party but hurts the other party when the total outside option is fixed. However, here the total outside option is a function of the two parties' investments. 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 enhances the former party's investment incentives.

Situations under which the hypothesis of part (b) of Proposition 2 hold, i.e. when one consultant's investment has a bigger impact on the other's outside identity than on their own, are not hard to find in reality. For example, in Ford's recent crisis with its Explorer, even though it is generally believed that the exceptionally high roll-over rate of the parpular model was due to defects in the tires produced by Firestone, one of Ford's biggest worries was that customers would stop buying the model even though the problematic tires were replaced.[4] Given the importance of the Explorer to Ford's revenue, one can imagine that Firestone's investment in preventing this problem in advance might have had a bigger impact on Ford's identity than on Firestone's.

2.3 Alternating-offers bargaining

In the property rights approach to the theory of the firms, Chiu [3] and De Meza and Lockwood [10] show that some important results of GHM, such as ownership always enhances investment incentives, can be overturned if the bargaining structure is changed from Nash bargaining to alternating-offer bargain. This section examines whether the same difference exists under the current framework. Again, consider organization structure $O(\alpha, \beta)$, where $\alpha \in [0,1]$ and $\beta \in [0,1]$. Under alternating-offer bargaining, consultant A or consultant B's reservation value will not matter unless their individual rationality (IR) constraint binds. We can follow the procedure of De Meza and Lockwood [10] and partition the space of feasible investment $\mathcal{A} \times \mathcal{B}$

[4] See 'Tyre straits', Aug 31st 2000, the Economist.

into following three regions,

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

In $R_0(\alpha,\beta)$, neither consultant A nor consultant B's IR constraint binds. In $R_A(\alpha,\beta)$, consultant A's IR constraint binds but consultant B's does not. In $R_B(\alpha,\beta)$, consultant B's IR constraint binds but consultant A's does not. This allows us to write consultant A and consultant B's payoffs as

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

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

Without loss of generality, assume that consultant B's IR constraint never binds, so we can ignore the case of $(a,b)\in R_B(\alpha,\beta)$. Consequently, Nash equilibrium can be one of the following two possibilities: $(a_0, b_0) \in R_0(\alpha, \beta)$ and $(a_A, b_A) \in R_A(\alpha, \beta)$, where

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

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

$$\frac{1}{2}[A(a,b) + B(a,b)] - \alpha \underline{A} - (1-\beta)\underline{B} = 0. \tag{7}$$

By applying the implicit-function theorem to (7), we have

$$\frac{db}{da} = -\frac{\frac{1}{2}[A_a + B_a] - \alpha \underline{A}_a - (1-\beta)\underline{B}_a}{\frac{1}{2}[A_b + B_b] - \alpha \underline{A}_b - (1-\beta)\underline{B}_b} \tag{8}$$

For simplicity, the following assumption allows us to focus on the case in which the boundary between set R_0^I and R_A^I is downward sloping.

Assumption 1: $\frac{db}{da} < 0$.[5]

[5] This assumption holds whenever $\frac{1}{2} > \phi$ and has the same effect as Assumption 4 of De Meza

In equation (8), $\frac{1}{2}[A_a + B_a] \equiv MB^{A0}$ is the marginal benefit of consultant A's investment when consultant A's IR constraint is not binding, $\alpha \underline{A}_a + (1-\beta)\underline{B}_a \equiv MB^{AA}$ is the marginal benefit of consultant A's investment when consultant A's IR constraint is binding, $\frac{1}{2}[A_a + B_a] \equiv MB^{B0}$ is the marginal benefit of consultant B's investment when consultant A's IR constraint is not binding, and $[A_b + B_b] - \alpha \underline{A}_b - (1-\beta)\underline{B}_b \equiv MB^{BA}$ is the marginal benefit of consultant B's investment when consultant A's IR constraint is binding. For ease of presentation, (8) can be written as

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

The following analysis focuses on pure-strategy Nash Equilibrium of the following two possible cases under Assumption 1.[6]

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 $b_A > b_0$ (because $MB^{BA} > MB^{B0}$) and $a_0 > a_A$ (because $MB^{A0} > MB^{AA}$) in Case 1 and that $b_A < b_0$ (because $MB^{BA} < MB^{B0}$) and $a_0 < a_A$ (because $MB^{A0} < MB^{AA}$) in Case 2. We label this preliminary result Lemma 3.

Lemma 3 *In Case 1, the binding of consultant A's IR constraint will decrease con-*

and Lockwood [10].

[6] We ignore any mixed-strategy Nash equilibrium because it will not entail any qualitative change in the results.

sultant A's investment and increase consultant B's investment. In Case 2, the binding of consultant A's IR constraint will increase consultant A's investment and decrease consultant B's investment.

One of the important results of Chiu [3] and De Meza and Lockwood [10] is that *ownership* might be bad for investment incentives. This is parallel to Lemma 3, which states that *outside recognition* can causes employees' IR constraint to bind and decrease their investment.

Lemma 1 of the previous section shows that there is always underinvestment regardless of the ownership structure when consultants A and B bargain under the Nash bargaining structure. This is due to the hold-up problem, and changing the bargaining structure to alternating-offer bargaining should not change this underlying feature. Lemma 4 verifies this.

Lemma 4 *If consultants A and B bargain under the alternating-offers bargaining structure, there will be underinvestment under any organization structure $O(\alpha, \beta)$. That is, if a^T and b^T are the equilibrium investment levels when consultants A and B bargain under the alternating-offers bargaining structure, then*

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

Proof. From Lemma 3 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 Lemma 1's proof. The proof of $b^T < b^*$ is symmetric. ■

In comparing any change of organization structure, one of the major concerns is whether the change will cause consultant A's IR constraint to bind, which in turn will cause a discrete jump (Case 1) or fall (Case 2) in her investment. To be more specific, for any two organization structures $O(\alpha, \beta)$ and $O(\alpha', \beta')$ if consultant A's IR constraint is binding under $O(\alpha', \beta')$ but not under $O(\alpha, \beta)$, then we know from Lemma 3 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 consultant A's IR constraint is binding under both $O(\alpha, \beta)$ and $O(\alpha', \beta')$, then consultant A's payoff is $\alpha \underline{A} + (1-\beta)\underline{B} - a$, and consultant 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 can $O(\alpha', \beta')$ if and only if $\alpha \underline{A}_a + (1-\beta)\underline{B}_a > \alpha' \underline{A}_a + (1-\beta')\underline{B}_a$, and $O(\alpha, \beta)$ can induce higher investment from B than can $O(\alpha', \beta')$ if and only if $\alpha \underline{A}_b + (1-\beta)\underline{B}_b < \alpha' \underline{A}_b + (1-\beta')\underline{B}_b$.

If consultant A's IR constraint is not binding under either $O(\alpha, \beta)$ or $O(\alpha', \beta')$, then consultant A's payoff is $\frac{1}{2}[A+B] - a$ and consultant B's payoff is $\frac{1}{2}[A+B] - b$.

In this case, the boundaries of the firms do not matter because α and β do not enter either A or consultant B's payoff function. Proposition 3 summarizes the above results.

Proposition 3 *Given any two organization structures* $O(\alpha, \beta)$ *and* $O(\alpha', \beta')$,

- *If consultant A's IR constraint 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 does* $O(\alpha', \beta')$ *in Case 1, and* $O(\alpha, \beta)$ *induces lower investment from A and higher investment from B than does* $O(\alpha', \beta')$ *in Case 2.*

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

- *If consultant A's IR constraint is binding under neither* $O(\alpha, \beta)$ *nor* $O(\alpha', \beta')$, *then the boundaries of the firms do not matter.*

3 The Repeated Investment Game – Relational Contracts

The previous two sections assume that neither the outputs (consultants A and B) nor the investments (a and b) are contractible. However, in a repeated relationship, a desirable investment or output level by one party might be enforced by the threat of future punishment from the other party. Baker, Gibbons and Murphy [1] referred to such types of enforcement as 'relational contracts' and showed that firm boundaries still matter when the investment game is repeated and parties can sign relational contracts. This section extends 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' (where the investment game is not repeated) gross benefit of consultants A and B, respectively. For any given $O(\alpha,\beta)$, the equilibrium investment levels a^S and b^S maximize (3) and (4)[7], i.e.

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

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

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

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

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

Hence, the equilibrium investment $\left(a^R, b^R\right)$ of the repeated investment game must satisfy

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

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

In accordance with Baker, Gibbons and Murphy [1], we assume that after any party reneges on the relational contract, the two parties live forever under spot governance with the optimal ownership structure $O(\alpha^*, \beta^*)$, where $(\alpha^*, \beta^*) = \arg\max_{(\alpha,\beta)} A(a,b) + B(a,b) - a - b$ subject to equations (5), (6), and $\alpha \leq 1$ and $\beta \leq 1$.[8] Denote $U^{SA}\left(a^S(\alpha^*,\beta^*), b^S(\alpha^*,\beta^*), \alpha^*, \beta^*\right)$ as U^{SA*} and $U^{SB}\left(a^S(\alpha^*,\beta^*), b^S(\alpha^*,\beta^*), \alpha^*, \beta^*\right)$

[8] Suppose that second order conditions are satisfied.

as U^{SB*}. We know that the condition for A to honor the relational contract is

$$U^{RA}\left(a^R, b^R\right) + \frac{1}{r}U^{RA}\left(a^R, b^R\right) \geq \max_a U^{SA}\left(a, b^R, \alpha, \beta\right) + \frac{1}{r}U^{SA*}, \tag{9}$$

and the condition for B to honor the relational contract is

$$U^{RB}\left(a^R, b^R\right) + \frac{1}{r}U^{RB}\left(a^R, b^R\right) \geq \max_b U^{SB}\left(a^R, b, \alpha, \beta\right) + \frac{1}{r}U^{SB*}. \tag{10}$$

Summing the two yields

$$\begin{aligned} & \frac{1}{r}\left[U^{RA}\left(a^R, b^R\right) - U^{SA*} + U^{RB}\left(a^R, b^R\right) - U^{SB*}\right] \qquad (11) \\ \geq\ & \max_a U^{SA}\left(a, b^R, \alpha, \beta\right) - U^{RA}\left(a^R, b^R\right) + \max_b U^{SB}\left(a^R, b, \alpha, \beta\right) - U^{RB}\left(a^R, b^R\right). \end{aligned}$$

where the left hand side is the net present value of the total future punishment if one party reneges and the right hand side is the total temptation to renege. Because for any relational contract $\left(U^{RA}, U^{RB}\right)$ that satisfies (11) there is 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 (9) and (10), without loss of generality we can focus on (11) 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 contracts does not render a particular ownership structure *always* dominant – ownership structure matters. In this section, two analogous results are obtained under the new definition of the firms.

First, by examining (11) we know that organization structure affects the total temptation to renege, which in turn determines the feasibility of a relational contract. This straightforward result is analogous to (i) and is labeled Proposition 4.

Proposition 4 *Whether a given relational contract is feasible depends on the underlying organization structure.*

The intuition behind (ii) is that relational contracts cannot mimic spot bargaining. This can also be seen under the current framework. 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 because the left hand side of (11) 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 because the right hand side of (11) is

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

which is nonnegative. Hence, (11) will not hold. This result is summarized in Corollary 1.

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

4 Conclusion

By introducing a new definition of the firms, this paper extends the incomplete-contract framework of the property-rights approach to the theory of the firms, and establishes a new theory that places people at the centers of the firms. The new definition can totally ignore physical assets and view a firm as a group of people who work in a close relationship so that external markets cannot distinguish them individually. This new definition helps to explain the merger of human-capital intensive firms such as professional service firms. In addition, a new role of externalities in determining boundaries of the firms is presented.

These results can also be applied to other types of firms, as long as integration entails some identity blurring among the integrating parties. However, the firms defined here may look different to firms defined legally in practice, because it is difficult to define a firm in terms of intangible elements such as outside identification. Nevertheless, we believe the new definition captures some important aspects of the firms. The model is very simple, so it should be easy to extend in future work. One possible extension is to allow investing parties to fight for outside identification.

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. Che and D. Hausch, Cooperative Investments and the Value of Contracting, *American Economic Review*, **89** 1, 1999, 125-147.

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

[4] M. Dewatripont, I. Jewitt, and J. Tirole, The Economics of Career Concerns, Part I: Comparing Information Structures, *Review of Economic Studies*, **66**, 1999, 183-198.

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

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

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

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

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

[10] 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.

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

[12] 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.

[13] S. Tadelis, What's in a Name? Reputation as a Tradable Asset, *American Economic Review*, **89** 3, 1999, 548-63.

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