Asset Ownership and Investment Incentives Revisited

First version: January 1999
This version: August 1999

Abstract

Previous work on the property rights theory of the ...rm suggests that in the presence of outside options, asset ownership may demotivate managers. This paper shows that this conclusion relies on the assumption that a manager's outside option only depends on her own investment. In many cases, an asset owner has the opportunity to continue with a project even if the team breaks up. The investments of non-owners may then be devalued, but are typically not wholly lost to the owner. This weakens the bargaining power of the non-owner. So, in the presence of cross e¤ects, outside options do not necessarily overturn the property of the original Grossman-Hart-Moore model that an asset transfer may motivate the gainer and demotivate the loser.

1. Introduction

Whether for good or ill, managers often have in‡uence well beyond their tenure in a job. Examples are so numerous as to be commonplace. Chandler (1977) recounts that the American railroad network took its modern form by the 1880s and "...salaried career executives played a critical role in the system building of the 1880s" (p167). Irreversible investment decisions aside, a theme of Peters and Waterman (1982) is that e¤ective managers inculcate an enduring culture. Typical is the quote of Richard Deupree, former CEO of Procter and Gamble, "William Procter and James Gamble realized that the interests of the organization and its employees were inseparable. That has never been forgotten." (p76). This paper examines the implications of such persistence for the property rights theory of the ...rm (PRT).

The property rights theory of the ...rm (PRT) is a bold attempt to explain the main features of industrial organization in terms of the incentive e¤ects of asset ownership. The seminal papers by Grossman and Hart (1986) and Hart and Moore (1990), henceforth GHM, established the general framework of this approach. Inability to verify the extent to which agents make relationship-speci...c investments means that contracts are necessarily incomplete and can always be renegotiated. Eventual payo¤s, and consequently the ex ante incentive to invest, are therefore determined by ex post bargaining. As ownership of non-human assets a¤ects bargaining power, ownership ultimately in‡uences the ex ante incentive to invest. The boundary of the ...rm (that is, the extent to which assets are under common ownership) is thus determined by the ownership structure that provides the best bundle of incentives.

It turns out, however, that the qualitative predictions of the PRT are sensitive to the bargaining protocol. In GHM, the Nash axiomatic bargaining solution is applied. That is, post investment, the revenue division is that each manager obtains what they could get by working alone (individual revenue), plus half the di¤erence between what they could get by working together (team revenue) and the sum of individual revenues.[1] This outcome is also the solution of an alternating-o¤er game as the managers become very patient (i.e. as a common discount rate tends to zero), when the individual revenues are available during bargaining, so called inside options. Assuming - as GHM do - that investment raises the value of individual revenue as well as that of the team, this 'split-the-surplus' solution means ownership unambiguously raises an agent's incentive to make relationship-speci…c investments[2].

Two recent papers (Chiu (1998) and De Meza and Lockwood (1998)) reconsider the class of models studied by GHM under the alternative assumption that individual revenues are outside options which, when taken, preclude further bargaining. In this case, as emphasized by De Meza and Lockwood, it is quite possible that asset ownership may demotivate managers. For example, suppose that there is only one asset, and that ownership of the asset boosts the outside option of the owner by so much that his outside option always binds at the bargaining stage, given choice of equilibrium investments. Then, in equilibrium, the owner equates his marginal cost of investment to the marginal e¤ect of investment on individual revenue, whereas the non-owner, being the "residual claimant", equates his marginal cost of investment to the marginal e¤ect of investment on team revenue.

[1] The more general case with n managers is dealt with by Hart and Moore(1990).

[2] This result is formally stated and proved as Proposition 1 below.

Now, a basic assumption of the PRT is that, for any manager, the marginal e¤ect of investment on team revenue is greater than that on individual revenue (Hart(1995)). It follows that with outside options, a transfer of the asset from manager i to manager j will cause manager i to invest more, and manager j to invest less. This paper presents a result below (Proposition 2) which shows that the above line of argument applies quite generally[3]; under some weak assumptions, a manager's incentive to invest is maximized when owning no assets.

Although there may be occasions where ownership demotivates, it is surely unrealistic that it virtually always does so. This paper o¤ers a way out by dropping the assumption, common to most of the earlier property rights literature, that if the relationship breaks up, all of the non-owner's investment is lost to the owner. It is shown that if managers' investments augment the value of the physical asset(s) as well as their own human capital, the conclusion of the earlier property rights literature (namely, that asset ownership motivates) can be restored even when the outside option principle applies.[4]

[3] De Meza and Lockwood(1998) show that with outside options, incresed ownership motivates only under rather special conditions namely ; (i) if the manager's outside option is already binding before he is given the asset; or, (ii) if the outside option is initially not binding on either manager, but becomes binding on the recipient following transfer o the asset, and the recipient's outside option is relatively sensitive to investment (i.e. the return on investment in the outside option is more than half the return to investment in team production). See also Chiu(1998) for similar results. Both (i) and (ii) require some asymmetry in the model. In particular, although both these cases involve the manager gaining the asset investing more, the manager losing the asset does not invest less (and in the second case invests strictly more). So even here the investment incentives of one of the managers is at a maximum when they own no assets.

[4] Noldeke and Schmidt (1998) allow investments to augment physical assets but work in a

The mechanism at work is the following. If the team breaks up, the subsequent revenue generated by the owner of the asset depends on the investment made by the non-owner, insofar as that investment is embodied in the physical asset. In this paper, we call the (marginal) impact of an agent's investment on the individual revenue of the other agent a cross-effect. To illustrate the qualitative significance of cross effects for the property-rights theory suppose the outside option of an asset owner is binding at the bargaining stage so the non-owner is the residual claimant. With cross-effects, the non-owner's marginal return to investment is now the increase in team revenue less the boost in the owner's outside option due to the cross-effect. The cross effect thus weakens the non-owner's investment incentive since, to the extent investment augments asset value, it merely serves to strengthen the owner's bargaining power. Consequently, ownership may once more motivate.

The key ingredient of our approach, that the value of the owner's outside option depends on the investment of the other agent(s), is natural and realistic in many settings. For example, consider the "widget" model of a vertical production relationship used by Grossman and Hart(1986), Hart(1995). Suppose that one of the assets is a widget-making machine, and that the manager of the widget-producing firm has invested some time making improvements to that machine. Then, if the manager of the downstream firm owns this asset, in the event of individual production, (i.e. the managers do not agree to produce and trade a specialized widget), the manager of downstream firm obtains some benefit from the other manager's time investment[5]. The situation is similar when an employee

Nash bargaining framework and are concerned with different results.

[5] This variant of Hart's model is discussed in detail in Section 4.

makes organizational improvements, or when a scientist makes a discovery but the company owns the patent[6]. The ownership issue could also involve who has the right to work in progress, the value of which generally depends on the contribution of all team members. In all these cases, even in the presence of outside options, ownership may enhance incentives.

2. An Example

As a simple illustration, consider the chef-skipper example of Hart and Moore (1990). A chef and a skipper can provide a luxury cruise. The skipper can make an unverifiable investment at a personal cost of 11 which raises total cruise revenue from 80 to 100. We suppose that this consists of researching charts to provide a particularly suitable itinerary. If the team breaks up prior to the voyage and the skipper owns the vessel, he can use it to provide an inferior cruise, which earns him 60 if the investment has been made and 50 otherwise. Without the yacht, the skipper's investment is wasted and his best alternative earning opportunity is 20. If the team breaks up and the chef owns the yacht, she gets 50, but only 20 if she does not own it. So, for now the individual revenue of the chef is independent of the skipper's investment (i.e. there are no cross-effects).

Now consider investment incentives if post-investment bargaining is Nash axiomatic. First, suppose the skipper owns the yacht. If he invests, his payoff is 60+0.5(100-60-20)=70 whereas without investment the payoff is 50+0.5(80-50-

[6] All these examples assume that the investment of the non-owner augments the physical capital of the owner of the asset. However, a similar effect might arise if the investment is in human capital. For example, suppose an engineer trains an assistant to repair the machine before he leaves.

20)=55. So, as 70-55 >11, the investment is undertaken. When the chef owns, the skipper gets 20+0.5(100-20-50)=35 if he invests, and if he does not, he gets only 20 +0.5(80-20-50)=25. In this case, his gain from investment is less than 11 and he does not invest. So the efficient investment only takes place if the skipper, the sole party with an investment choice, is the owner. As income transfers can be made ex ante, this ownership structure is the one that will be agreed at the outset. This first case illustrates the original GHM theory of the firm.

Now consider how matters turn out if the outside option principle applies, as in de Meza and Lockwood(1998). When the skipper owns the yacht, his outside option is binding at the bargaining stage, as it is worth more than 50% of team revenue whether or not he invests. Hence, the skipper gets 60 with investment and 50 without, and consequently does not invest. When the chef owns, her outside option binds, and so the skipper gets 80-50=30 without investment and 100-50=50 with, implying that the skipper now wishes to invest. It is now efficient for the chef to own, because only if the skipper does not own is he sufficiently motivated to invest.

Finally, retain the outside option principle, but suppose that when the skipper invests, in addition to researching charts (which augments only the skipper's human capital), he also supervises modifications to the keel of the yacht to allow easy access to more ports on the itinerary (which augments the value of the physical asset). This additional work raises the skipper's investment cost by 5 taking it to 16[7]. In the event negotiations breakdown irretrievably, the gain from easier port access is worth 10 whoever owns the yacht. There are now cross-effects i.e.

[7] We suppose for simplicity that investment is still binary i.e. either the skipper does both the keel adjustment and the chart research, or neither.

the skipper's investment augments the value of the yacht to the chef if the chef owns it.

So, if the chef owns and the skipper invests, the chef's outside option increases from 50 to 60. Therefore, when the chef owns, the skipper's gain from investing is now only (100-60)-(80-50)=10, less than the cost of investment of 11+5=16. On the other hand, when the skipper himself owns, investment raises his now raises his outside option from 50 to 70, more than the investment cost of 16. So, we are back to the original GHM conclusion i.e. the skipper can only be sufficiently motivated to invest if he owns.

3. The Model

In this Section, we present our model, which can be thought of as an extension of Hart's (1995, ch2) widget model, to accommodate cross-effects. There are two managers $i = 1, 2$ engaged in a vertical production relationship using two indivisible assets a_1, a_2. Specifically, 2 works with an asset a_2 to produce a widget which is then passed to 1 who works with a_1 to produce a final output. Investments at levels e_1, e_2; $0 \le e_i < \infty$; are made by managers 1,2 at date 0 and the widget is supplied at date 1:

Following Hart, we interpret investments e_1, e_2 as being money or time spent improving the efficiency of the relevant manager's operation. There is uncertainty about the type of the widget manager 1 requires, which is resolved at date 1; consequently, an effective long-term contract is impossible. Rather, at date 1, the parties negotiate about the widget price and type from scratch. Finally, both parties are risk-neutral and have unlimited wealth so that it is feasible for each party to own any asset that is it efficient for him to own.

The first possibility is that the managers trade a "specialized" widget, an event we refer to as team production. In this case, manager 1 gets payoff $R(e_1) - p^*$, where p^* is the price - negotiated at date 1- at which they trade, and R is the revenue from the sale of the widget. Similarly, manager 2 gets a payoff $p^* - C(e_2)$; where C is the cost of producing the widget. So, the total profit (ignoring investment costs) from team production is $\Pi = R - C$: We assume that R is strictly concave and differentiable in e_1 and C is strictly convex and differentiable in e_2:

The second possibility is that the two managers do not agree to trade, an event we call individual production. Let the payoffs to individual production be $\pi^1; \pi^2$: In general, π^i may depend both on investments $e_1; e_2$ and on the set of assets owned by i: Indeed, it is central to the theory that π^1 (resp. π^2) depend also on the set of assets that manager 1 (resp. manager 2) owns. Recall that in the example discussed in the previous section, the individual revenue of either the skipper or the chef depended on whether that agent owned the yacht.

Following Hart(1995), we consider two possible allocations of assets between the managers; non-integration, where manager 1 owns a_1, and manager 2 owns a_2; and integration, where one manager owns both assets (there are obviously two possibilities here). Formally, an asset allocation is a pair $(\alpha_1; \alpha_2)$ where $\alpha_i \in \{\emptyset; \{a_i\}; \{a_1; a_2\}\}$ is the set of assets owned by $i = 1; 2$, and $\alpha_1 \cup \alpha_2 = \{a_1; a_2\}$; $\alpha_1 \cap \alpha_2 = \emptyset$: Let the set of all possible asset allocations be A: So, we write $\pi^i(e_1; e_2; \alpha_i)$ to denote the value of individual production to i under different asset allocations.

In modelling individual production, we wish to capture cross-effects. In Hart(1995), there are no cross-effects i.e. π^1 is independent of e_2, and π^2 is independent of

e_1. One way of interpreting this is the following. Hart assumes that the two managers have an additional input to production other than the non-contractible investments, which he calls "human capital" (Hart(1995), p36). It is an implicit assumption in Hart that in the absence of 2's human capital, 1 simply cannot produce a widget, and similarly, in the absence of 1's human capital, 2 simply cannot produce the final product.

However, even if (for example) manager 1 can produce a widget in the absence of manager 2, this is not in itself sufficient to generate cross-effects. There must still be a mechanism[8] by which an increase in e_2 can lower the cost to 1 of producing a widget with individual production. We propose the following such mechanism, which we believe to be empirically plausible. Interpret $a_1; a_2$ as machines (or factories) that make the final product and the widget respectively. We will suppose that the investments $e_1; e_2$ consist in part of modifications to the relevant machines, and we denote by $0 \leq \lambda_2 < 1$ the fraction of 2's investment that is embodied in the widget-making machine (perhaps 2 has made some improvement to the speed or reliability of the machine) and similarly denote by $0 \leq \lambda_1 < 1$ the fraction of 1's investment that is embodied in the machine that produces the final product. So, in the event that team production does not take place, manager 1 has "access" to investment $\lambda_2 e_2$ of manager 2, and similarly for manager 2. Parameters $\lambda_1; \lambda_2$ are crucial in what follows.

Now suppose that team production does not take place. If 1 owns both ma-

[8] The mechanism we propose is not the only mechanism that generates cross-effects. For example, if investments augment the productivity of assets, higher investment by manager 2 may raise the revenue of manager 1 in the event he owns both assets, even though he may not be able to produce the widget.

chines, he has three options. First, he can buy a standard widget at price p and produce final output. Second, he can produce a standard widget with machine a_1, and use it in conjunction with a_2 to produce final output. Third, he can produce his own specialized widget with machine a_1, and use it in conjunction with a_2 to produce final output.

Denote the revenues from the second stage of individual production using specialized and standard widgets by $r(e_1)$; $\tilde{r}(e_1)$ respectively. Also, from the definition of λ_2 above, the costs to 1 of producing a specialized and standard widget with asset a_2 are $c(\lambda_2 e_2)$; $\tilde{c}(\lambda_2 e_2)$: It is natural to assume that revenue is higher if a specialized widget is used, and that such a widget is more costly to produce (i.e. $r > \tilde{r}$, $c > \tilde{c}$), but neither of these assumptions is necessary in what follows. All we assume is that if 1 owns both assets, he prefers to produce the specialized rather than the standard widget, no matter what the investment levels i.e.

$$r(e_1) - c(\lambda_2 e_2) > \tilde{r}(e_1) - \tilde{c}(\lambda_2 e_2); \text{ all } e_1; e_2 \tag{3.1}$$

Second, if 1 has only asset a_1, he can only buy a standard widget and produce the final good using this widget, or remain inactive. Finally, we suppose that without either machine, agent 1 can produce nothing[9]. A convenient simplifying assumption is that $\tilde{r}(0) > p > \tilde{c}(0)$ i.e. it is always better for manager 1 to buy a standard widget and produce the final output if he owns a_1, rather than remain inactive, and for manager 2 to produce and sell the standard widget if he owns a_2; rather than stay inactive. So, using above assumptions, the net revenue to

[9] This assumption seems very weak; the discussion in Hart(1995) makes it clear that in the model, assets are to be thought of as necessary for team production, so we simply assume the same of individual production.

manager 1 in these three cases is;

$$
\begin{aligned}
\pi^1(e_1, e_2 &: a_1, a_2) = r(e_1) - c(\lambda_2 e_2) \qquad (3.2)\\
\pi^1(e_1, e_2 &: a_1) = \bar{r}(e_1) - p\\
\pi^1(e_1, e_2 &: \emptyset) = 0
\end{aligned}
$$

By similar arguments, we can write down the net revenue for manager 2 in the event that no team production takes place. If he has no assets, he cannot produce anything. If he only has the second asset, it is both feasible and optimal for him to produce a standard widget for sale to the spot market. If he has both assets, he has the same three options as manager 1 did in the same case, the only difference being that 2 only benefits from fraction λ_1 of 1's investment. Also, we assume that if 2 owns both assets, he prefers to produce a specialized rather than a standard widget;

$$r(\lambda_1 e_1) - c(e_2) > \bar{r}(\lambda_1 e_1) - \bar{c}(e_2); \text{ all } e_1, e_2 \qquad (3.3)$$

So, we have;

$$
\begin{aligned}
\pi^2(e_1, e_2 &: a_1, a_2) = r(\lambda_1 e_1) - c(e_2) \qquad (3.4)\\
\pi^2(e_1, e_2 &: a_2) = p - \bar{c}(e_2)\\
\pi^2(e_1, e_2 &: \emptyset) = 0
\end{aligned}
$$

We assume that $r, \bar{r}$ are increasing and strictly concave, and $c, \bar{c}$ are decreasing and strictly convex, in their arguments.

We now turn to the key issue of cross-effects. Note that the model is set up in such a way that when $\lambda_1, \lambda_2 > 0$; with integrated ownership, there are cross-effects i.e.

$$\frac{\partial \pi^1(e_1, e_2 \mid a_1, a_2)}{\partial e_2} = -\lambda_2 c'(\lambda_2 e_2) > 0, \quad \frac{\partial \pi^2(e_1, e_2 \mid a_1, a_2)}{\partial e_1} = \lambda_1 r'(\lambda_1 e_1) > 0 \tag{3.5}$$

On the other hand, with non-integration, there are no cross-effects. When agent 1 owns only asset a_1, he must buy a widget from the spot market at price p, (and similarly for 2) and so the payoff to manager i from individual production is independent of j's investment. So, we have the important observation that in a fully specified model, cross-effects are determined endogenously by the structure of asset ownership.

Finally, note that when $\lambda_1, \lambda_2 = 0$, our model is almost the same as that of Hart(1995). There are only two inessential differences. In Hart, agents engaged in individual production are assumed transact on the spot widget market[10], whatever assets they own. By contrast, in our model, (i) when an agent owns both assets, he finds it both feasible and profitable to make the specialized widget and use it as an input (by (3.1),(3.3)), and (ii) an agent with no assets cannot produce at all. However, these are superficial differences, for the reason that the key assumptions in Hart's model are also satisfied in our model, as we now show.

We now wish to impose the assumptions on Π, π^1, π^2 made in Hart-Moore(1990) and Hart(1995), so that we can compare our results with theirs in a meaningful way. The assumptions[11] are:

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[10] In Hart(1995), payoffs from individual production for agents 1,2 are specified as follows: $\pi^1(e_1, e_2 \mid \alpha_1) = r(e_1 \mid \alpha_1) - p$, $\pi^2(e_1, e_2 \mid \alpha_2) = p - c(e_2 \mid \alpha_2)$.

[11] Our Assumption 1 corresponds to part of Assumption 2 of Hart-Moore(1990), and Assumption 2.1 of Hart(1995). Our Assumption 2 corresponds to Assumption 6 of Hart-Moore(1990), and Assumptions 2.2, 2.3 of Hart(1995).

Assumption 1. $\phi > \pi^1 + \pi^2$; all $e_1; e_2$, all $(\alpha_1; \alpha_2) \in A$:

This assumption implies that team production will always take place. For Assumption 1, it is sufficient that $R(e) - C(e') > r(e) - c(e')$; all $e; e'$: The justification for this is the same as in Hart(1995), namely that with individual production, manager i no longer has access to j's human capital.

Assumption 2. $\frac{\partial \phi(e_i)}{\partial e_i} > \frac{\partial \pi^i(e_i; a_1; a_2)}{\partial e_i} \geq \frac{\partial \pi^i(e_i; a_i)}{\partial e_i} \geq \frac{\partial \pi^i(e_i; \emptyset)}{\partial e_i} \geq 0$; all $e_1; e_2$:

This says that the marginal return to investment in individual production is (weakly) increasing in the number of assets owned, and is always strictly less than the marginal return to investment in the relationship. Also, at least one of the weak inequalities in Assumption 2 should hold strictly for the PRT to be non-trivial. For Assumption 2 to be satisfied, we require that $r'(e) \geq \tilde{r}'(e) \geq 0$; $c'(e) \leq \tilde{c}'(e) \leq 0$ i.e. investment by manager 1 has a higher marginal return if the final product is made using a specialized widget, and similarly investment by manager 2 has a higher marginal return if the specialized widget is produced.

The assumptions made so far imply the following useful intermediate result.

Lemma 1. (Free disposal of assets) The payoff to individual production π^i is non-decreasing in the number of assets owned by i:

This result follows directly from (3.2)-(3.4) and the assumption that $\tilde{r}(0) > p > \tilde{c}(0)$:

The order of events is as follows. First, the non-contractible investments $e_1; e_2$ are made. Then, once investments are made, agents bargain over the revenue from team production. Finally, production and consumption take place. We solve the model backwards in the usual way to locate the subgame-perfect equilibrium.

4. Bargaining

The way in which the revenue from team production is divided up depends on the assumed bargaining protocol i.e. the rules of the bargaining game. One way to think of the two alternatives studied in this paper is to think of both as bargaining games whose basic structure is alternating-offers. In GHM, a protocol is assumed which effectively treats $\pi^1; \pi^2$ as inside options. That is, each agent gets π^i per period while bargaining over the division of Π. The interpretation of this is that the two agents can engage in individual production whilst bargaining; this may be an appropriate assumption in some cases.

In this case, in the limit as the discounting goes to zero, it is well-known (e.g. Sutton(1986)) that the equilibrium payoff for each party is the inside option payoff plus half the net gain from trade;

$$v^1(e_1; e_2) = \pi^1 + \frac{1}{2}\left[\Pi - \pi^1 - \pi^2\right] \quad (4.1)$$

$$v^2(e_1; e_2) = \pi^2 + \frac{1}{2}\left[\Pi - \pi^1 - \pi^2\right] \quad (4.2)$$

where we have suppressed the dependence of $v^1; v^2$ on $(\alpha_1; \alpha_2)$ for convenience.

By contrast, more recent work by De Meza and Lockwood(1998) and Chiu(1998) assume a bargaining protocol where $\pi^1; \pi^2$ are outside options. Here, it is assumed that agents cannot engage in individual production while bargaining. Rather, in any bargaining round, the responder may irrevocably leave the bargaining process and commence individual production. In this case, it is well-known (Binmore, Shaked and Sutton(1989), Sutton(1986)), that in the limit as the common rate of discounting goes to zero, the equilibrium payoffs at the bargaining stage may be characterized as follows.

Given some arbitrary investment levels $(e_1; e_2)$; and asset ownership structure $(\alpha_1; \alpha_2)$, say i's outside option is binding, if

$$\frac{\Sigma(e_1; e_2)}{2} < \pi^i(e_1; e_2; \alpha_i)$$

Then, if neither outside option is binding, each manager gets $\Sigma/2$. If 1's outside option is binding, then he gets π^1, and manager 2 gets $\Sigma - \pi^1$ i.e. 2 is "residual claimant". If 2's outside option is binding, then he gets π^2, and manager 1 gets $\Sigma - \pi^2$ i.e. 1 is "residual claimant". By Assumption 1, these are the only possibilities. Let these payoffs[12] as functions of $e_1; e_2$ be $w^1(e_1; e_2)$; $w^2(e_1; e_2)$:

5. Results on Investment and Asset Ownership

We begin with the inside option case. At date 0, managers 1 and 2 choose e_1 and e_2 respectively to maximize their payoffs net of investment costs, $v^1(e_1; e_2) - e_1$, $v^2(e_1; e_2) - e_2$ (we have set the unit cost of each type of investment to unity for convenience). Note from inspection of (4.1),(4.2) and the properties of $\Sigma; \pi^1; \pi^2$ that the optimal e_1 is independent of e_2 and vice versa. So, for each asset allocation, by the strict concavity of $r; \tilde{r}; R$; and the strict convexity of $c; \tilde{c}; C$; there will be a unique pair of optimal investments $e_1^*; e_2^*$. Note also that - crucially - $e_1^*; e_2^*$ depend on the asset allocation. As remarked above, Hart's(1995) widget model is effectively a special case of our model without cross-effects (i.e. $\lambda_1; \lambda_2 = 0$). In that case, we know that when the payoffs from individual production are inside options, investment is increasing in asset ownership (se e.g. De Meza and Lockwood(1998)) This first result extends straightforwardly when cross-effects are introduced.

[12] For explicit formulae for these two payoffs, see De Meza and Lockwood(1998).

Proposition 5.1. With inside options, manager 1's (resp. 2's) investment e_1^* (resp. e_2^*) is (weakly) increasing in the number of assets he owns, even when cross-effects are present. Moreover, the larger the cross-effects λ_1, λ_2 the lower is investment by the non-owner under integrated ownership.

Proof. Consider first manager 1. The general formula for his payoff gross of investment cost is given by (4.1) i.e. $v^1(e_1; e_2) = \pi^1 + \frac{1}{2}[\Sigma - \pi^1 - \pi^2]$. Substituting in our formulae for $\pi^1; \pi^2$, we get

$$v^1(e_1; e_2; a_1; a_2) = r(e_1) - c(\lambda_2 e_2) + 0{:}5\,(R(e_1) - C(e_2) - r(e_1) + c(\lambda_2 e_2)) \quad (5.1)$$

$$v^1(e_1; e_2; a_1) = \tilde{r}(e_1) - p + 0{:}5\,(R(e_1) - C(e_2) - \tilde{r}(e_1) + \tilde{r}(e_1)) \quad (5.2)$$

$$v^1(e_1; e_2; \emptyset) = 0{:}5\,(R(e_1) - C(e_2) - r(\lambda e_1)) \quad (5.3)$$

in obvious notation. So, if manager 1 owns both assets, from (5.1), his optimal choice of e_1 is given by

$$\frac{1}{2}R'(e_1) + \frac{1}{2}r'(e_1) = 1 \quad (5.4)$$

If he owns one asset, from (5.2), his optimal choice of e_1 is given by

$$\frac{1}{2}R'(e_1) + \frac{1}{2}\tilde{r}'(e_1) = 1 \quad (5.5)$$

and if he owns none, from (5.3), his optimal choice of e_1 is given by

$$\frac{1}{2}R'(e_1) - \frac{\lambda_1}{2}r'(\lambda_1 e_1) = 1 \quad (5.6)$$

The first result then follows from (5.4)-(5.6), the concavity properties of $R; r; \tilde{r};$ and Assumption 2 in the context of the cross-effects model i.e. $r' \geq \tilde{r}' \geq 0$: Also, the solution to (5.6) is clearly decreasing in λ_1. A similar argument applies for manager 2. ∎

This result shows that the most basic implication of the inside option bargaining protocol is that asset ownership motivates, and moreover, this conclusion is robust to the introduction of cross-effects. Note that the higher is λ_1 or λ_2; the lower is the investment by the non-owner. Intuitively, with a cross-effect, more investment by the non-owner simply increases the owner's outside option, and therefore his bargaining power, and the stronger the cross-effect, the stronger this loss of bargaining power for the non-owner is.

We now turn to the case of outside options. In this case, the payoffs in the investment stage are then $w^1(e_1; e_2) - e_1; w^2(e_1; e_2) - e_1$. Contrary to the inside option case, there is strategic interaction at the investment stage in that optimal investment for 1 depends on 2's investment and vice-versa. We will assume that there is a unique pure strategy Nash equilibrium $e_1^*; e_2^*$ to this investment game. For conditions sufficient to guarantee this, see De Meza and Lockwood (1998). This Nash equilibrium is of course conditional on a given asset allocation.

Say i's outside option is binding in equilibrium if in the equilibrium of the investment game,

$$\frac{\phi(e_1^*; e_2^*)}{2} < \pi^i(e_1^*; e_2^*; \alpha_i)$$

Of course, which, if either, outside option is binding in equilibrium depends on the asset allocation. We now make one more, quite weak assumption:

Assumption 3. For either manager, there exists an asset allocation such that his outside option is binding in equilibrium.

This is quite a weak assumption. It rules out (i) a trivial case, where neither manager's outside option ever binds, in which case asset ownership can never affect investment, or (ii) the case where the model is highly asymmetric. Under these assumptions, we can now get the following general result about the e¤ect of asset ownership on investment:

Proposition 5.2. Suppose Assumptions 1-3 hold and there are no cross-e¤ects ($¸_1; ¸_2 = 0$). With outside options, the investment of either manager is strictly higher when he has no assets than two assets, and weakly higher than when he owns no assets rather than one.

Proof. (i) We …rst show that if a manager owns one asset, and his outside option is binding in equilibrium, his outside option is also binding in equilibrium when he owns two assets.

Suppose to the contrary that manager 2's outside option is only binding when he owns one asset. Let his equilibrium payo¤ net of investment cost in this case be $u^¤$. Now suppose manager 2 acquires the second asset and provisionally let 1's investment be unchanged at the initial equilibrium level $e_1^¤$. By assumption, 2 now picks an investment e_2^0 that makes his outside option non-binding. But then by Lemma 1, his outside option would also be non-binding at the same investment levels $(e_1^¤; e_2^0)$ if he owned only one asset. So, his payo¤ given $(e_1^¤; e_2^0)$; u^0; is then the same as it would have been in the case when he owned only one asset. But in the equilibrium with one asset, manager 2 does not choose e_2^0; so by strict convexity of $c; C$ he must get a higher payo¤ i.e. $u^¤ > u^0$:

Now if manager 2 were to invest the same as when he owned the single asset (say $e_2^¤$), the outside option must still bind (by Lemma 1), and so he could achieve a payo¤ is at least as great as $u^¤$. Consequently; 2 can do strictly better if he chooses $e_2^¤$ rather than e_2^0, contrary to assumption.

Let $e_2^*; e_2^{**}$ be the equilibrium investment levels of 2 when 2 owns one or two assets respectively, and suppose consistently with the above, that 2's outside option binds in both cases. To complete the proof, we only need to show that 1 will invest the same in both equilibria, confirming the maintained hypothesis about his behaviour. It is certainly a local maximum for 1 to invest the same in the two cases (in both, 2's optimal investment is given by $R'(e_1) - 1 = 0$ as his payoff is $\Pi - \pi^2 - e_1$ in both cases). Moreover, it is easy to check that given $e_2^*; e_2^{**}$; as e_1 rises from zero, first 2's outside option is binding whether he owns one or two assets for e_1 low, then only binding when he owns two assets for an intermediate range of e_1; then not binding in either case for e_1 high. This plus strict concavity of $r; \bar{r}; R$ in e_1, and the fact that $\bar{r}' < r' < R'$ from Assumption 2, implies that 1's payoff w^1 is globally concave in e_1; so that the local maximum must also be a global maximum for 1.

(ii) It follows that if manager i owns two assets, his outside option must be binding in equilibrium. For suppose not. Then from (i), his outside option cannot be binding when he has one asset either. Also, by assumption, his outside option is zero when he has no assets, and so cannot bind either. But then Assumption 3 is violated.

(iii) Now consider manager 1. If he has no assets, manager 2 must have both, and so from (ii), manager 2's outside option is binding. Therefore, manager 1's payoff is $\Pi - \pi^2 - e_1$: The first-order condition for his optimal investment is therefore

$$R'(e_1) = 1 \tag{5.7}$$

so by Assumption 2, his investment can be no higher under any other allocation of assets. If manager 1 has both assets, his payoff is $\pi^1 - e_1$, as his outside option is binding, so the first-order condition for his optimal investment is

$$r'(e_1) = 1 \tag{5.8}$$

and so from (5.7),(5.8), by Assumption 2, and strict concavity of $R; r;$ his investment must be strictly lower than when he owns neither asset. The proof for manager 2 is symmetric. □

This is the most general possible formulation of the idea that with outside options, asset ownership may demotivate. This result consolidates Propositions 4 and 5 of De Meza and Lockwood(1998), and extends them to the case of relatively productive outside options[13]. It also relates to Proposition 3 of Chiu (1998), which says that if asset transfer causes the manager receiving the asset to invest strictly more, then the donor invests (weakly) more. So, under the stated condition, losing an asset motivates, and consequently, under the reverse asset transfer, the additional asset will demotivate the recipient.

The key focus of this paper is whether asset ownership motivates with cross-effects when $\pi^1; \pi^2$ are outside options. On this question, we have the following result;

Proposition 5.3. Suppose Assumptions 1-3 hold and that the return to investment in individual production is relatively high ($r'(e) > 0.5R'(e);\ -c'(e) > -0.5C'(e)$). Then, with outside options, when cross-effects are sufficiently strong ($1 > \lambda_1; \lambda_2 > \lambda_0$); the investment of either manager is strictly higher when he has two assets than no assets.

[13] These occur when the marginal product of investment in individual production is at least half the marginal product of investment in team production. For a more formal definition, see Section 4 below.

Proof. Consider manager 1. If he has no assets, the other manager must have both, and so from Assumption 3, manager 1's payoff is $\Pi - \pi^2 - e_1$. Writing this in full,

$$\Pi - \pi^2 - e_1 = R(e_1) - C(e_2) - r(\lambda_1 e_1) + c(e_2)$$

So, the first-order condition for his optimal investment is

$$R'(e_1) - \lambda_1 r'(\lambda_1 e_1) = 1$$

If manager 1 has both assets, again from Assumption 3, his payoff is $\pi^1 = r(e_1) - c(\lambda_2 e_2)$; so the first-order condition for his optimal investment is

$$r'(e_1) = 1$$

Now, by strict concavity of R, r, his investment in the second case is higher iff

$$r'(e) > R'(e) - \lambda_1 r'(\lambda_1 e) \tag{5.9}$$

But if $r'(e) > 0.5R'(e)$, there is an λ_0 such that (5.9) holds for $1 > \lambda_1 > \lambda_0$. The proof for manager 2 is symmetric. $\square$

So, with strong cross-effects, the rather general result that in the presence of outside options asset ownership demotivates is (partially) reversed; integrated ownership by 1 raises 1's investment relative to integrated ownership by 2, and vice versa. Notice that Proposition 3 also implies that Chiu's result that if an asset acquiring manager invests more, so must the asset losing manager, does not extend to the case of cross effects.

The remaining case is non-integration. Assume for simplicity that with non-integration, outside options do not bind in equilibrium. Below, we show by means of an example that this will generally occur for a range of values of p, the market widget price. Then, with non-integration, the investment level for manager 1 will be given by

$$0.5R'(e_1) = 1$$

Now, by definition, if the return to investment in individual production is relatively high, then

$$r'(e) > 0.5R'(e) > R'(e) - r'(e)$$

So, for $\lambda_1 \simeq 1$,

$$r'(e) > 0.5R'(e) > R'(e) - \lambda_1 r'(\lambda_1 e) \tag{5.10}$$

But the three terms in (5.10), reading from left to right, are simply the marginal returns to investment by manager 1 when he owns two, one or no assets respectively. It follows directly from this fact and strict concavity of r, R, that investment is monotonically increasing the number of assets owned. A similar argument applies to manager 2. So we have;

Proposition 5.4. Suppose Assumptions 1-3 hold, that the return to investment in individual production is relatively high, and that outside options do not bind in equilibrium with non-integration. Then, with outside options, when cross-effects are sufficiently strong ($1 > \lambda_1, \lambda_2 > \lambda_0$), the investment of either manager is strictly increasing in the number of assets owned.

So, under some not too strong conditions, the presence of sufficiently strong cross-effects can completely reverse the effect of asset ownership on investment. If these conditions hold, therefore, the effect of transferring ownership of additional asset(s) to a manager is to induce him to invest more, irrespective of the precise bargaining protocol.

We now show by means of an example that the hypotheses of Propositions 3 and 4 can simultaneously be satisfied.

Example.

In this example, $R(e) = R_0 + \sqrt{e_1}$; $C(e) = C_0 - \sqrt{e_2}$; $r(e) = R_0 - \delta + \theta\sqrt{e_1}$; $\bar{r}(e) = R_0 - \delta + \gamma\sqrt{e_1}$; $c(e) = C_0 + \delta - \theta\sqrt{e_2}$, $\bar{c}(e) = C_0 + \delta - \gamma\sqrt{e_2}$, $\delta, \theta, \gamma > 0$, $1 > \theta > \gamma$ and finally, $\lambda_1 = \lambda_2 = \lambda$. Note that Assumptions 1-3 are certainly satisfied. Also, investment is relatively productive in the outside option if $\theta > 0.5$. Finally, (3.1) and (3.3) are satisfied as $\theta > \gamma$.

Next, we show that if $\theta > 0.5$, and δ is small, Assumption 4 is satisfied i.e. with integrated ownership, the owner's outside option is binding for λ sufficiently close to 1. Suppose w.l.o.g. that 2 owns both assets. Then his outside option is binding for some fixed e_1, e_2 if

$$r(\lambda e_1) - c(e_2) > \frac{R(e_1) - C(e_2)}{2}$$

But this reduces to

$$R_0 - C_0 - 2\delta + \theta(\sqrt{\lambda e_1} + \sqrt{e_2}) > 0.5(R_0 - C_0) + 0.5(\sqrt{e_1} + \sqrt{e_2}) \qquad (5.11)$$

Now, assuming that it is binding, it is easy to check that the optimal investment levels are given by

$$e_1 = \frac{1}{4}(1 - \sqrt{\lambda}\theta)^2; \; e_2 = \frac{1}{4}\theta^2 \qquad (5.12)$$

So, substituting (5.12) back in (5.11), 2's outside option is binding in equilibrium if

$$R_0 - C_0 - 2\delta + 0.5\theta(\sqrt{\lambda}(1 - \sqrt{\lambda}\theta) + \theta) > 0.5(R_0 - C_0) + 0.25((1 - \sqrt{\lambda}\theta) + \theta)$$

which surely holds if $\delta \simeq 0$, and $\lambda \simeq 1$, as $\theta > 0.5$.

Finally, we show that for a range of spot prices, the outside options are not binding in equilibrium with non-integration, as required by Proposition 4. For some fixed $e_1; e_2$, outside options are not binding if

$$0.5(R_0 - C_0) + 0.5(\sqrt{e_1} + \sqrt{e_2}) \geq R_0 - \delta + \gamma\sqrt{e_1} - p;\ p - C_0 - \delta + \gamma\sqrt{e_2} \quad (5.13)$$

If outside options are not binding in this case, it is easy to check that investment levels are $e_1 = e_2 = 1/16$. So, substituting these values back in (5.13), and rearranging, gives

$$0.5(R_0 + C_0) + \delta + \frac{(1-\gamma)}{4} \geq p \geq 0.5(R_0 + C_0) - \delta - \frac{(1-\gamma)}{4} \quad (5.14)$$

So, if p is in the interval (5.14), then neither outside option is binding, as required. So, we conclude that all the hypotheses of Propositions 3 and 4 are satisfied for this example. □

Finally, note two other novel implications of cross-effects. First, if λ is small, integration may increase the investment of both managers under the hypotheses of Proposition 3. This is clear as with non-integration, investments are determined by the conditions $0.5R' = 1;\ -0.5C' = 1$, but with integration with 2 owning (for example), and $\lambda = 0$, investments are determined by the conditions $R' = 1;\ -c' = 1$. So, clearly manager 1 will invest more with integration. As return to investment in individual production is relatively high, $-c' > -0.5C'$, so from the strict convexity of $c; C$, 2 will also invest more. This possible "double incentivisation" of asset reallocation has already been noted by Chiu(1998), but in an example where $e_1; e_2$ were strategic complements in Π; rather than additively separable.

Introducing cross effects also creates the possibility that diversified ownership may be optimal even with a binding outside option. Suppose that agent 1 works with asset a_1 and agent 2 with asset a_2. Let each agent's investment increase the value of the asset they work with but have no e¤ect on the other asset. Suppose initially that 1 owns both assets and her outside option binds. Now asset a_2 is transferred to manager 2, but this still leaves 1's outside option binding. Since the cross e¤ect is eliminated, 2's investment increases whereas 1's is una¤ected. Diversi…ed ownership therefore dominates both assets being owned by manager 1. Were ownership concentrated in 2's hands it might be that 2's outside option binds, in which case his investment falls relative to the diversi…ed solution. Whether 1 invests less depends on the e¤ect on team productivity relative to the impact on his outside option, but whatever happens to 1's investment, diversi…ed ownership may be best even though there is a binding outside option.

6. Conclusions

GHM explain the pattern of asset ownership by means of an incomplete contracting framework. Ownership matters for ex-ante investment decisions because of its in‡uence on ex-post bargaining. Their detailed analysis is most naturally interpreted in terms of the e¤ect of ownership on inside options. Yet in many settings it seems more natural that ex-post bargaining between managers involves the threat of outside options being exercised. That is, negotiation is driven by the consequences of team members committing to alternative employment arrangements. As ownership enhances a manager's opportunities, it may make the threat to break up the team credible, in which case the owner's payo¤ is determined by the outside option. The owner's incentive to raise the value of their own …rm is therefore dulled. The striking implication is that, for at least one manager, and usually both, investment incentives are maximized when no assets are owned.[14]

This paper shows that the demotivating e¤ect of ownership relies on the assumption that a manager's outside option only depends on her own investments. In many cases this is unrealistic. An owner typically has the right to continue with a project even if the team dissolves. The investment that the non owner made to enhance productivity may then be devalued, but is not normally wholly lost to the project. Indeed, the leading example in the property rights literature, the widget model, naturally exhibits the cross-e¤ect property under integrated ownership. This matters, for if at least some of the worker's investment is available to the owner even without cooperation, the bargaining power of the non owner is weakened, diminishing her incentive to invest. Moreover, if the owner's investment is complementary with the non-human assets, the investments she makes may be largely preserved if the team breaks up. So, in the realistic case that cross e¤ects are present, the GHM property that ownership motivates may extend to the case of outside options.

7. References

Binmore,K, A.Shaked, and J.Sutton (1989), "An outside option experiment", Quarterly Journal of Economics, 104, 753-770

Chandler, A.D.(1977) "The Visible Hand; The Managerial Revolution in American Business" Belknap Press, Cambridge, Mass

Chiu, Y.S. (1998) "Noncooperative Bargaining, Hostages and Optimal Asset Ownership" American Economic Review, 88, 882-901

[14] The circumstances where this applies to only one manager are given in footnote 3.

De Meza,D. and B.Lockwood(1998), “Does Asset Ownership Always Motivate Managers? Outside Options and The Property Rights Theory of the Firm”, Quarterly Journal of Economics, 113, 361-386

Grossman,S.J., and O.Hart (1986), “The costs and bene…ts of ownership: a theory of vertical and lateral integration”, Journal of Political Economy, 94, 691-719

Hart,O.(1995), Firms, Contracts, and Financial Structure, Oxford University Press

Hart,O., and J.Moore (1990), “Property rights and the nature of the …rm”, Journal of Political Economy, 98, 1119-1158

Noldeke, G. and K. Schmidt (1998) ”Sequential Investments and Options to Own” Rand Journal of Economics, Winter, vol.29 (4) 633-653.

Peters,T and R.H.Waterman (1982) ”In Search of Excellence” Harper Collins

Sutton,J.(1986), “Non-cooperative bargaining theory: an introduction”, Review of Economic Studies, 53, 709-724