Nature of Human Capital, Technology and Ownership of Public Goods

Maija Halonen-Akatwijuka
University of Bristol

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Abstract

Besley and Ghatak (2001) show that public good should be owned by the agent who values the public good most. They state that their result holds irrespective of technological factors. In this paper we show that relative valuations are not the sole determinant of optimal ownership structure but also technology and nature of human capital matter.

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1 Introduction

Besley and Ghatak (2001) extend the property rights theory of Grossman-Hart-Moore to public goods. Their main result is that the agent who cares most about the public good should be the owner "regardless of whether this party is also the key investor, or other aspects of the technology" (p.1343). This paper shows that the latter statement is not actually true. Valuation of public good is an important determinant of the optimal ownership structure but technology matters too.

Default payoffs determine the bargaining position of the parties and their incentives. The only determinant of default payoff that Besley and Ghatak (BG) examine is spillovers: how much of an agent's human capital is sunk in the project. We look more carefully into another characteristic of human capital: the indispensability of an agent. Indispensability measures how much of the *owner's* human capital cannot be realized without the worker. Relaxing the assumption that BG make about indispensability, we show that valuation of public good is not the sole determinant of optimal ownership structure even in the case where only one party makes an investment.

Suppose two agents are involved in producing the public good. The agents differ in how they value the public good: h's valuation is higher than l's. Since they are producing public good everyone can consume it. The main insight of BG is that when l increases his investment, h's default payoff is increased by more than l's default payoff (because of his higher valuation) resulting in worse bargaining position for l. To minimize this negative effect it is better to choose an ownership structure where l's investement contributes least to the default payoffs. This is the case when h is the owner: then only the part of l's investment that is sunk contributes to the project. Ownership by the high-valuation agent also provides the best incentives for h. Therefore both agents' incentives are improved when the high-valuation agent owns the public good.

However, there is also role for nature of human capital. Suppose that h does not have investment but he is indispensable: without h in the team l's human capital is not productive. Suppose also that some of l's human capital is sunk in the project. Now the ownership structure that minimizes the negative effect is l-ownership. If l owns the public good and cannot reach an agreement with h, l's investment does not contribute at all to the public good since l's investment is unproductive without h in the team. Ownership by the low-valuation agent is optimal – contrary to BG – because of properties of human capital.

Furthermore, we introduce a vertical structure into public good production. Two assets are needed for producing the public good and the complementarity of the assets determines the default points under nonintegration. We know that for private goods nonintegration emerges for economically independent assets, while integration is optimal for strictly complementary assets (Hart and Moore (1990)). With public goods these results can be turned over. Both valuations and technology matter but their combination gives rise to surprising results.

This paper adds to the small literature that has further examined BG and in essence shown that we cannot base policy advice solely on relative valuations of public goods. Francesconi and Muthoo (2007) introduce impurity of public goods and show, among other things, that technology determines optimal ownership structure when degree of impurity is large enough. In our paper even with pure public goods technology matters. Halonen-Akatwijuka and Pafilis (2007) analyze a repeated version of BG and show that elasticity of investments, in addition to the relative valuations, determines the optimal ownership structure. In this paper technology matters even in the static game.

2 The model

We build on Besley and Ghatak (2001) and firstly examine the nature of human capital embedded in their assumptions. In our basic model there are two players, l and h, with project-specific investment in human capital, y_l and y_h. Public good is produced and the benefit from the project is $b(y_l, y_h)$. The players value the project differently: l's utility from the public good is $\theta_l b(y_l, y_h)$ and h's utility is $\theta_h b(y_l, y_h)$. We assume that $\theta_l \leq \theta_h$, that is l is the low-valuation agent and h is the high-valuation agent. The investment costs are linear $c(y_i) = y_i$.

We assume that ex ante contract can only be written on the ownership of the project. We compare ownership by l and h. The timing is the following:

1. l and h contract on ownership of the project

2. l and h invest in project-specific human capital

3. l and h bargaining over completion of the project and produce the public good

Default payoffs play an important role in the analysis. If bargaining breaks down and i is the owner, the benefit from the project is $B^i(y_l, y_h)$. Each agent values this benefit differently: l's utility is $\theta_l B^i(y_l, y_h)$ and h's utility is $\theta_h B^i(y_l, y_h)$. Producing together is efficient: $B^i(y_l, y_h) < b(y_l, y_h)$. We furthermore make an assumption about marginal investment returns that is weaker than Assumption 1 in BG. Denote $b_i(y_l, y_h) = \frac{\partial b(y_l, y_h)}{\partial y_i}$ and $B_i^j(y_l, y_h) = \frac{\partial B^j(y_l, y_h)}{\partial y_i}$.

Assumption 1. $b_i(y_l, y_h) \geq B_i^i(y_l, y_h)$ and $b_i(y_l, y_h) \geq B_i^j(y_l, y_h)$ for $i, j = l, h$ and $i \neq j$.

If bargaining breaks down, the owner can exclude the non-owner from taking part in the *production* of the public good but cannot exclude him from *consuming* the public good. Therefore non-owner's investment has less effect on the benefit from the project if bargaining breaks down. This explains $b_i(y_l, y_h) \geq B_i^j(y_l, y_h)$. The gap between $b_i(y_l, y_h)$ and $B_i^j(y_l, y_h)$ depends on how much of the non-owner's investment is sunk in the project. We call this spillover.[1] The gap is small when investment is e.g. about designing and organizing the project implementation and plans are already adopted or written down. In this situation spillover is large and when the worker leaves, a large part of his investment is already sunk in the project. The gap is largest when all of the investment is embedded in the person e.g. charismatic leadership. Then there is no spillover and if the agent leaves, he takes the investment with him and $B_i^j(y_l, y_h) = 0$.

The gap between $b_i(y_l, y_h)$ and $B_i^i(y_l, y_h)$ depends on how the value of the owner's human capital investment depends on the presence of the other agent. If the other agent is dispensable, the owner's marginal value of investment does not depend on whether the worker is in the same coalition or not. Then $B_i^i(y_l, y_h) = b_i(y_l, y_h)$. While if the owner's human capital is productive only in conjunction with the other agent - the worker is indispensable - we have $B_i^i(y_l, y_h) = 0$.

BG assume that $b_i(y_l, y_h) \geq B_i^i(y_l, y_h) > B_i^j(y_l, y_h)$. However, spillovers and indispensability of an agent are clearly different properties of the human

[1] De Meza and Lockwood (2004) explore spillovers in the private goods case.

capital. Suppose for instance that agent h is indispensable. Without h in the team l's human capital is not productive: $B_l^l(y_l, y_h) = 0$. Suppose also that some of l's human capital is sunk in the project: $B_l^h(y_l, y_h) > 0$. Such a situation violates BG assumption since $B_l^h(y_l, y_h) > B_l^l(y_l, y_h)$ and yet can occur naturally. Agent h's indispensability does not in any way imply that there should be no spillovers from l's investment.[2] We explore how relaxing this assumption affects the optimal ownership of public good.

3 First best

Joint surplus equals

$$(\theta_l + \theta_h)\, b(y_l, y_h) - y_l - y_h$$

Therefore the first best investments are characterized by

$$(\theta_l + \theta_h)\, b_l(y_l^*, y_h^*) = 1 \tag{1}$$

$$(\theta_l + \theta_h)\, b_h(y_l^*, y_h^*) = 1 \tag{2}$$

Due to incompleteness of contracts we cannot obtain first best. In what follows we examine which ownership structure gives second best incentives.

4 Ownership and incentives

When l owns the public good (denoted by superscript l) Nash bargaining gives the following payoffs to the agents.

$$\begin{aligned} u_l^l &= \theta_l B^l(y_l, y_h) + \frac{1}{2}(\theta_l + \theta_h)\left[b(y_l, y_h) - B^l(y_l, y_h)\right] - y_l \\ &= \frac{1}{2}(\theta_l + \theta_h)\, b(y_l, y_h) + \frac{1}{2}(\theta_l - \theta_h)\, B^l(y_l, y_h) - y_l \end{aligned}$$

[2] And strictly speaking even that violates BG assumption since they assume $B_i^i(y_l, y_h) > B_i^j(y_l, y_h)$ with strict inequality.

$$
\begin{aligned}
u_h^l &= \theta_h B^l(y_l, y_h) + \frac{1}{2}(\theta_l + \theta_h)\left[b(y_l, y_h) - B^l(y_l, y_h)\right] - y_h \\
&= \frac{1}{2}(\theta_l + \theta_h) b(y_l, y_h) + \frac{1}{2}(\theta_h - \theta_l) B^l(y_l, y_h) - y_h
\end{aligned}
$$

Optimal investments are then given by

$$\frac{1}{2}(\theta_l + \theta_h) b_l(y_l, y_h) + \frac{1}{2}(\theta_l - \theta_h) B_l^l(y_l, y_h) = 1 \tag{3}$$

$$\frac{1}{2}(\theta_l + \theta_h) b_h(y_l, y_h) + \frac{1}{2}(\theta_h - \theta_l) B_h^l(y_l, y_h) = 1 \tag{4}$$

The first term in (3) and (4) shows that each agent shares 50:50 his contribution to the total value of the public good. The second term is negative for the low-valuation agent and positive for the high-valuation agent. It shows how an increase in investment affects the agent's bargaining position. Since this is a public good both parties can consume it even if they cannot reach an agreement. Therefore higher investment increases both parties' default payoffs. Since h values the public good more, his default payoff increases more than l's default payoff. That is why the second term is negative for l. l's higher investment improves h's bargaining position relative to l. While h's higher investment increases both the size of the pie and his share of it and therefore the second term in (4) is positive. Comparing the incentives to (3) and (4) we can verify that there is a familiar holdup problem.

It is straightforward to derive the incentives under h ownership:

$$\frac{1}{2}(\theta_l + \theta_h) b_l(y_l, y_h) + \frac{1}{2}(\theta_l - \theta_h) B_l^h(y_l, y_h) = 1 \tag{5}$$

$$\frac{1}{2}(\theta_l + \theta_h) b_h(y_l, y_h) + \frac{1}{2}(\theta_h - \theta_l) B_h^h(y_l, y_h) = 1 \tag{6}$$

Comparing how incentives depend on ownership structure boils down to comparing the second terms in (3) and (4); and (5) and (6). Incentives are higher under h ownership if

$$\frac{1}{2}(\theta_l - \theta_h)\left[B_l^h(y_l, y_h) - B_l^l(y_l, y_h)\right] > 0 \tag{7}$$

$$\frac{1}{2}(\theta_h - \theta_l)\left[B_h^h(y_l, y_h) - B_h^l(y_l, y_h)\right] > 0 \tag{8}$$

If $B_l^l(y_l, y_h) > B_l^h(y_l, y_h)$ and $B_h^h(y_l, y_h) > B_h^l(y_l, y_h)$ (the assumptions made by BG) then indeed ownership of the high-valuation agent gives the best incentives to both h and l. h-ownership maximizes the positive second term for h and minimizes the negative second term for l. But some properties of human capital are embedded in these assumptions. To make our case clear we first discuss an example with one investment and then come back to the general setup of the model.

4.1 One investment

Suppose only l invests. Then we only need to examine equation (7). Suppose h is indispensable, $B_l^l(y_l, y_h) = 0$. Without h in the team l's human capital is not productive. Suppose also that some of l's human capital is sunk in the project and so $B_l^h(y_l, y_h) > 0$. In this case ownership by the low-valuation party is optimal since $B_l^l(y_l, y_h) < B_l^h(y_l, y_h)$. Therefore relative valuations are not the only determinant of optimal ownership structure but also the nature of human capital plays an important role. Spillovers and indispensability are different characteristics of human capital. Assuming that h's indispensability implies that there can be no spillovers from l's human capital is restrictive.

Ownership by l is optimal – not because l is the only investor (as it would be in the private goods case) – but because the optimal ownership structure minimizes the negative second term in l's incentives. His investment has minimal effect on default payoffs when he himself is the owner. Since h is indispensable l's investment is unproductive without h and higher investment is not going to worsen his bargaining position under l ownership.

Note that this does not only turn around BG result but also the result obtained in the private goods case. In Hart and Moore (1990) an indispensable agent should own the asset, but in this case h is indispensable and l ownership is optimal.

4.2 Two investments

Now we come back to the two investments case. From (7) and (8) we can see that optimal ownership structure depends, in addition to relative valuations, on $B_i^i(y_l, y_h) - B_i^j(y_l, y_h)$. We have four possible cases.

If both $B_l^l(y_l, y_h) > B_l^h(y_l, y_h)$ and $B_h^h(y_l, y_h) > B_h^l(y_l, y_h)$, then ownership by the high-valuation agent is optimal. These are the BG assumptions and they hold e.g. when there are no spillovers $\left(B_i^j(y_l, y_h) = 0\right)$ and neither agent is indispensable $(B_i^i(y_l, y_h) > 0)$.

If both $B_l^l(y_l, y_h) < B_l^h(y_l, y_h)$ and $B_h^h(y_l, y_h) < B_h^l(y_l, y_h)$, then ownership by the low-valuation agent provides the best incentives for both agents. Then the positive second term for h is maximized under l-ownership since $B_h^h(y_l, y_h) < B_h^l(y_l, y_h)$ and the negative second term for l is minimized under l-ownership since $B_l^l(y_l, y_h) < B_l^h(y_l, y_h)$. This is the case when e.g. both agents are indispensable $(B_i^i(y_l, y_h) = 0)$ and there are some spillovers $\left(B_i^j(y_l, y_h) > 0\right)$.

When the agents have asymmetric roles so that $B_i^i(y_l, y_h) > B_i^j(y_l, y_h)$ and $B_j^j(y_l, y_h) < B_j^i(y_l, y_h)$, then also the relative importance of investments plays a role. Suppose for example that agent i is indispensable $\left(B_j^j(y_l, y_h) = 0\right)$ and there are no spillovers from his investment $\left(B_i^j(y_l, y_h) = 0\right)$. While there are some spillovers from agent j's investment $\left(B_j^i(y_l, y_h) > 0\right)$ and he is not indispensable $(B_i^i(y_l, y_h) > 0)$. In such a situation agent i has better incentives under ownership by the high-valuation agent while agent j has better incentives under ownership by the low-valuation agent. Then the optimal ownership structure depends on the relative importance of investments. If agent i has got significantly more important investment, then h-ownership is optimal. While if j's investment is much more productive, it is important to maximize his incentives, which is provided by l-ownership.

We summarize these results in Propositions 1 and 2.

Proposition 1 *Ownership by the low-valuation agent is optimal if*
(i) $B_i^i(y_l, y_h) < B_i^j(y_l, y_h)$ *for* $i, j = l, h$ *and* $i \neq j$ *or*
(ii) $B_i^i(y_l, y_h) > B_i^j(y_l, y_h)$ *and* $B_j^j(y_l, y_h) < B_j^i(y_l, y_h)$ *for* $i, j = l, h$ *and* $i \neq j$ *and agent* j*'s investment is significantly more important than agent* i*'s investment.*

Proposition 2 *Ownership by the high-valuation agent is optimal if*
(i) $B_i^i(y_l, y_h) > B_i^j(y_l, y_h)$ *for* $i, j = l, h$ *and* $i \neq j$ *or*
(ii) $B_i^i(y_l, y_h) > B_i^j(y_l, y_h)$ *and* $B_j^j(y_l, y_h) < B_j^i(y_l, y_h)$ *for* $i, j = l, h$ *and* $i \neq j$ *and agent* i*'s investment is significantly more important than agent* j*'s investment.*

We will finally examine indispensability. In Hart and Moore (1990) an indispensable agent should be the owner. How is it with public goods? Examination of (7) and (8) gives the following Proposition.

Proposition 3 *If agent i is indispensable $\left(B_j^j\left(y_l, y_h\right) = 0\right)$,*

(i) agent j has best incentives under ownership by the low-valuation agent,

(i) agent i has best incentives under ownership by the low-valuation agent if and only if $B_i^i\left(y_l, y_h\right) < B_i^j\left(y_l, y_h\right)$.

Proof. Suppose h is indispensable $\left(B_l^l\left(y_l, y_h\right) = 0\right)$. Then (7) shows that agent l has best incentives under l-ownership and (8) shows that agent h has also best incentives under l-ownership if and only if $B_h^h\left(y_l, y_h\right) < B_h^l\left(y_l, y_h\right)$. Repeating this argument in the case where l is indispensable $\left(B_h^h\left(y_l, y_h\right) = 0\right)$ completes the proof. Q.E.D.

Proposition 3 says that if an agent is indispensable, then the other agent has best incentives under ownership by the low-valuation agent. When h is indispensable, l's negative second term is minimized under l-ownership because l's investment is unproductive without indispensable h. When l is indispensable, h's positive second term is maximized under l-ownership because of (potential) spillovers. Therefore simply taking into account that an agent might be indispensable turns over BG result. It cannot be true that both agents have best incentives under h-ownership if one of the agents is indispensable.

Proposition 3 also shows that although the nature of human capital matters for ownership of public goods, its role is different than in the private goods case. Hart and Moore (1990) actually assume that there are no spillovers. If we include spillovers, we do not get unambiguous result. But we can say that the more indispensable an agent is, the more likely it is that he owns the asset.[3] With public goods this is no longer true. According to

[3] In Hart and Moore's notation if we have 2 agents and one asset a, the incentives under ownership by agent 1 are: $\frac{1}{2}v^1\left(12, \{a\}\right) + \frac{1}{2}v^1\left(1, \{a\}\right) = c'(I_1)$ and $\frac{1}{2}v^2\left(12, \{a\}\right) - \frac{1}{2}v^2\left(1, \{a\}\right) = c'(I_2)$. $v^2\left(1, \{a\}\right)$ measures the spillover of 2's investment. While the incentives under 2 ownership are $\frac{1}{2}v^1\left(12, \{a\}\right) - \frac{1}{2}v^1\left(2, \{a\}\right) = c'(I_1)$ and $\frac{1}{2}v^2\left(12, \{a\}\right) + \frac{1}{2}v^2\left(2, \{a\}\right) = c'(I_2)$.

Now suppose 1 is indispensable $\left(v^2\left(2, \{a\}\right) = 0\right)$. 2's incentives under his ownership are weaker and therefore ownership by indispensable 1 is more likely. We do not get unambiguous result because ownership by agent 1 worsens agent 2's incentives due to spillovers that improve agent 1's bargaining position

Proposition 3 an indispensable high-valuation agent should own the public good if and only if $B_h^h(y_l, y_h) > B_h^l(y_l, y_h)$ and h's investment is important relative to l's investment. While an indispensable low-valuation agent should be the owner if (i) $B_l^l(y_l, y_h) < B_l^h(y_l, y_h)$ or (ii) $B_l^l(y_l, y_h) > B_l^h(y_l, y_h)$ and h's investment is important relative to l's investment.

In sum, the optimal ownership structure depends on three factors.

(i) The relative valuations for public good. Higher investment improves the bargaining position of high-valuation agent but worsens it for the low-valuation agent.

(ii) Under which ownership structure the agent's investment has greatest effect on the default payoffs $(B_j^j(y_l, y_h) - B_j^i(y_l, y_h))$. For the high-valuation agent we wish to maximize the marginal productivity of invesment under disagreement while for the low-valuation agent we wish to minimize it. Marginal productivities depend on spillovers and indispensability.

(iii) The relative importance of investments. In some cases there is a trade-off between providing good incentives to h or l. Then the relative importance of investments determines the optimal ownership structure.

We have shown that optimal ownership of public good is not solely determined by relative valuations for public good but also the nature of human capital (spillovers and indispensability) and technology (importance of investment) matter.

5 Vertical structure

We now introduce a vertical structure in the production of the public good. There is asset a_1 which produces input used by asset a_2 to produce the public good. Suppose agent h operates a_1 and agent l operates a_2 (their roles can be reversed without affecting our results). $B^N(y_l, y_h)$ is the surplus if bargaining breaks down under nonintegration. We assume that utilising assets a_1 and a_2 together is efficient: $B^N(y_l, y_h) < b(y_l, y_h)$. Furthermore, in line with Assumption 1 the marginal productivity of investment is greatest in the full coalition: $B_i^N(y_l, y_h) \leq b_i(y_l, y_h)$. We also assume there are no spillovers cross the assets. That is, agent h's investment can only spill over to asset a_1 and agent l's investment only to asset a_2.

Under nonintegration the incentives are

$$\frac{1}{2}(\theta_l + \theta_h) b_l(y_l, y_h) + \frac{1}{2}(\theta_l - \theta_h) B_l^N(y_l, y_h) = 1 \tag{9}$$

$$\frac{1}{2}(\theta_l+\theta_h)\, b_h(y_l,y_h)+\frac{1}{2}(\theta_h-\theta_l)\, B_h^N(y_l,y_h)=1 \tag{10}$$

While incentives under integration by h are as in equations (5) and (6). And equations (3) and (4) give incentives under l integration.

Suppose assets are strictly complementary: $B_i^N(y_l,y_h)=0$. There are no alternative trading partners. The second terms in (9) and (10) are equal to zero. Then nonintegration gives the best incentives for agent l while agent h has the worst incentives. This means that nonintegration is optimal for strictly complementary assets if agent l has very important investment. This is contrary to the private goods case where integration is optimal for strictly complementary assets. Integration is optimal in public goods case if agent h has relatively important investment.

Suppose (h,a_1) and (l,a_2) are economically independent. There are equally good alternative trading partners available. Then $B_i^N(y_l,y_h)=b_i(y_l,y_h)$ and $B_i^i(y_l,y_h)=b_i(y_l,y_h)$. Then the second terms are maximal under nonintegration. This gives best incentives for h whereas l has worst incentives under nonintegration. Nonintegration is then optimal if h's investments is relatively more important. While when agent l has got significantly more important investment, integration is optimal since it minimizes the negative second term. In the private goods case nonintegration is unambiguously optimal when assets are economically independent. This proves Proposition 3.

Proposition 4 (i) *Nonintegration is optimal for strictly complementary assets if and only if the investment of the low-valuation agent is significantly more important.*

(ii) *Integration is optimal for economically independent assets if and only if the investment of the low-valuation agent is significantly more important.*

Proposition 4 shows that the results of the private goods case with respect to degree of complementarity between the assets are reversed when low-valuation agent has important investment.

This further proves that relative valuations are not the sole determinant for public goods but technology matters too. And technology may work differently in the case of public goods than private goods.

6 Conclusions

We have examined ownership of public goods. Besley and Ghatak (2001) show how public good case differs from private good case in how investments affect default payoffs. In the private good case an agent's higher investment generally increases his default payoff and improves his bargaining position. While with public goods higher investment improves everybody's default payoffs since everyone can consume public good. Disagreement would only lead to the non-owner to be excluded from the *production* of the public good. Higher investment therefore increases high-valuation agent's default payoff by more than low-valuation agent's default payoff is increased. This is a disincentive for the low-valuation agent while it is a positive incentive for the high-valuation agent. Optimal ownership structure then minimizes the negative effect on the low-valuation agent and maximizes the positive effect on the high-valuation agent. BG show that ownership by the high-valuation agent does both since only the sunk part of low-valuation agent's investment contributes to the value of public good (and worsens l's incentives) when h is the owner. BG state that high-valuation agent should own the public good irrespective of technology.

In this paper we show that although relative valuation is an important determinant, it is not the only one but nature of human capital and technology matter too. Allocating ownership optimally is about maximizing the positive default payoff effect for h and minimizing the negative effect for l just as in BG but nature of human capital and technology have a role too. How investment affects the default payoffs depends on the following factors:

(i) indispensablity of the agent,

(ii) investment spillovers and

(iii) the degree of complementarity between the assets.

All of these factors affect optimal ownership structure, as is the case for private goods. However, the results of the private goods case may be overturned. It may be optimal to separate strictly complementary assets and it may be optimal to take away ownership from an indispensable agent.

References

[1] Besley, T. and M. Ghatak, (2001), "Government versus Private Ownership of Public Goods", *Quarterly Journal of Economics*, 116, 1343-72.

[2] De Meza, D. and B. Lockwood, (2004), "Spillovers, Investment Incentives and the Property Rigths Theory of the Firm", *Journal of Industrial Economics*, 52, 229-253.

[3] Francesconi, M. and A. Muthoo, (2006), "Control Rights in Complex Partnerships", mimeo.

[4] Halonen-Akatwijuka, M, and E. Pafilis, (2007), "Reputation and Ownership of Public Goods", mimeo.

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