Incomplete Property Rights and Overinvestment

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Abstract

I consider a model in which an asset owner must decide how much to invest in his asset mindful of the fact that an encroacher's valuation of the asset is increasing in the asset owner's investment. Due to incomplete property rights, the encroacher and asset owner engage in a contest over the control of the asset after investment has taken place. A standard result is that the asset owner will underinvest in the asset relative to the first-best level of investment when property rights are complete. Contrary to this standard result, I find that when the interaction between the asset owner and the encroacher is infinitely repeated and the encroacher has some bargaining power over the size of the transfer from the asset owner to him, then there is a cooperative equilibrium in which the asset owner finds it optimal to over-invest in the asset when property rights are incomplete relative to the first-best level of investment when property rights are complete. Overinvestment is used to induce cooperation. However, this result depends on the encroacher's bargaining power or, *more generally*, whether the transfer is an increasing function of investment.

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1. Introduction

It is widely accepted that the level of investment and creation of surplus in a country or by individuals in their assets depends on the security of property rights. Property rights affect economic performance. In recent years, this view has been forcefully expoused in De Soto (2000, 2001). De Soto (2001) argues that “[W]hat the poor lack is the easy access to the property mechanisms that could legally fix the economic potential of their assets, so that they could be used to produce, secure, or guarantee greater value in the expanded market … assets need a formal property system to produce significant surplus value.”

To be sure, De Soto (2000, 2001) focuses on formal, legal, and *direct* protection of property rights of the kind provided by the state. However, since the protection of protection rights is costly, it is unlikely that the state can provide complete property rights. In a world of such incomplete property rights, individuals and private agents also invest in property rights protection. And the state cannot fully protect property rights through direct enforcement. Therefore, even if private agents or the state take actions to protect their property rights, these actions need not be only direct investments in fighting those who challenge their property rights. For example, Allen (2002), drawing on the insights of Demsetz (1967), shows that an asset owner might have the incentive to reduce the value of his asset in order to make the asset less attractive to encroachers. In particular, the asset owner might destroy attributes of the asset which are valued by the encroacher but not valued by owner or are valued less highly by him (i.e., the owner). Allen (2002) presents many interesting examples to illustrate his point. For example, he argues that Rhinoceros in Africa and elsewhere are dehorned to reduce their value to poachers. Also, he argues that Monsato, the American seed company, purchased the "terminator gene" to make its plants sterile (unable to germinate) in order to reduce the value of its seed to seed pirates. He also applies this simple idea to penal colonies, the quality of office furniture in public buildings, toilet paper and soap dispensers in public washrooms, the quality of children's skis, snowboards, bikes, and other interesting phenomena. Konrad (2002) also finds that incomplete property rights lead to underinvestment or cannot lead to overinvestment. He applies his analysis to investments by managers within firms and by autocrats within countries.[1] In a similar but more elaborate model, Gonzalez (2005) also finds that when property rights are incomplete, it may be optimal to adopt inferior technologies even if a superior technology is costless.[2] Finally, there is an empirical literature that shows that weaker protection of protection rights lead to lower investment (e.g., see Besley, 1995; Goldstein and Udry, 2008, and the references therein).

Clearly, in Allen (2002), Konrad (2002), Gonzalez (2005) and Goldstein and Udry (2008), a lower investment is used as a deterrent to encroachers and so overinvestment is not possible. For example, in Gonzalez (2005) there are two technologies: an existing but inferior technology and a superior technology which can be adopted at zero cost. If property rights are complete, the first-best solution will be the adoption of the superior technology. Since there are only two technologies, the second-best environment of incomplete property rights cannot lead to the adoption of a better

[1]More importantly, Konrad (2002) examines how the advantages of incumbency affect the investment incentives of the incumbent.

[2]In a growth model with incomplete property rights, Gonzalez (2007) and Gonzalez and Neary (2008) show that it may be optimal to reduce the rate of economic growth. This result is in the spirit of Allen (2002), Konrad (2002) and Gonzalez (2005) although the analysis is undertaken in a much richer dynamic environment.

technology than the one adopted in the first-best case. Therefore, overinvestment is not possible.[3]

While property rights affect investment in assets, investments in an asset can also affect property rights. Besley (1995) discusses this endogeneity issue in his econometric analysis. The use of investments to enhance property rights is evident in Razzaz's (1993) work on squatters in Jordan. Razzaz (1993, p. 351) notes that the settlers "… know that a makeshift shelter stands little chance and that the more they invest in permanent material the more their claim to the land is legitimized." This suggests that if the settlers had complete property rights over the land, they would have invested less which is an indication of over-investment when property rights incomplete.

The asset owner may increase the value of the asset for strategic reasons. A higher value of the asset could be seen as a commitment device by the owner to credibly communicate to the encroacher that he (i.e., the owner) is willingly to spend enough resources to protect it. This may cause the encroacher to reduce his effort. Even if the higher value causes the encroacher to increase his effort, the owner might still find it optimal to increase the value of the asset if the increase in his effort is sufficiently greater than the increase in the encroacher's effort such that his probability of keeping the asset or the proportion of it that he appropriates is sufficiently high and the increase in the cost of effort required to achieve this outcome is sufficiently low.

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[3]Gonzalez (2005) is, however, not primarily concerned with the comparison of investment levels in first-best and second-best environments. His focus is a different but interesting question: *given* a second-best world, if an agent can adopt an inferior technology and a superior but costless technology, will he necessarily adopt the superior technology?

Although the preceding argument is intuitive and may be a potential reason for overinvestment, I find that it is unable to generate overinvestment in both complete information and incomplete information environments. I therefore extend the complete-information case to an infinitely-repeated game setting and find that overinvestment may be undertaken because it facilitates cooperation between the asset owner and encroacher. In this case, the asset owner makes a transfer to the encroacher in each period and in return the encroacher promises not to challenge the property rights of the asset owner. However, I show that whether this results in overinvestment whether the transfer is an increasing function of investment. It turns out that when the encroacher has some bargaining power over the size of the transfers, then the transfer is indeed an increasing function of the investment in the asset. The idea that transfers or redistribution can be used to induce cooperation, when property rights are incomplete, is not new. [4] The new result here is that the encroacher's bargaining power or, more generally, the relationship between the transfer and investment can lead to overinvestment.

The intuition for the overinvestment result is as follows: given that the transfer is increasing in the level of investment, cooperation is easier to sustain when there is overinvestment because it is costlier for the encroacher to renege on the agreement and suffer the consequence of losing this sufficiently high transfer forever.[5] This is what gives the crucial condition in the model that the critical discount factor must be decreasing in the level of investment. Yet, overinvestment will not always sustain cooperation because while it is imposes the threat of a relatively high punishment on the

[4]For example, see Amegashie (2008) and the references therein.

[5] In Skaperdas' (1992) static model in which there is no investment, cooperation is possible to sustain if the conflict success technology is sufficiently ineffective. This condition does not hold in my model.

encroacher, it is also makes the one-time gain from deviation relatively high since the value of the asset is higher when there is overinvestment compared to when there is no overinvestment. [6]

When the transfer is lump-sum (i.e., independent of investment), overinvestment is not optimal because it does not affect the magnitude of the punishment but increases the gain from deviation.

The motivation behind the preceding argument is related to an argument in Halonen (2002). In an infinitely-repeated prisoner's-dilemma type game within a Grossman-Hart-Moore framework[7] where take-it-or-leave-it transfers are made from one party to the another in order to sustain cooperation, Halonen (2002) shows that relative to single-ownership, joint-ownership of an asset has the desirable feature of imposing the threat of a higher punishment but has the undesirable feature of yielding a higher one-time gain from deviation. If the latter effect is sufficiently strong, then joint ownership is the optimal ownership structure. However, Halonen (2002) does not obtain the result of overinvestment in this paper.

My paper is also related to but different from a recent contribution by Robinson and Torvik (2005). In their paper, they opine that in the political economy of development, the issue of investments with negative social surplus is more important than underinvestment. In the case of Ghana under its first president, Kwame Nkrumah, Killick

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[6] Subsidies for activities like R&D financed by taxes can also lead to overinvestment. However, in this case there could be overinvestment even if the subsidy was financed by a lump-sum tax. To be sure, the idea that subsidies can lead to overinvestment is obvious and such arguments are different from the argument being made here. It is not obvious that a distortionary tax can lead to overinvestment. In the present model, it is the combination of incomplete property rights and transfers that are similar to distortionary taxes which account for overinvestment.

[7] This is the property-rights theory of the firm pioneered by Grossman and Hart (1986) and Hart and Moore (1990).

(1978, p.207) notes that “[T]he larger volume of ‘investment’ … could not compensate for the low-productivity uses to which it was put.” Indeed, as Robinson and Torvik (2005, note 2) argue “[T]he problem under Nkrumah was not underinvestment … the consensus view is that the capital stock increased by 80% between 1960 and 1965 … The problem was in the way this investment was allocated.” Using a model of political competition, Robinson and Torvik (2005) argue that such investments with negative social surplus (i.e., white elephants) could be seen as a credible promise to redistribute income to a segment of the electorate in order to influence the outcomes of elections in a world where politicians do not have complete property rights over power. However, my model and analysis differ from Robinson and Torvik (2005) in the following respects. First, I use a model of contest where efforts in the contest are not pure transfers. Second, overinvestment in my model does not lead to negative surplus. While overinvestment need not lead to a negative surplus, a negative surplus is an indication of overinvestment. My model cannot explain why an agent will invest in a white elephant while Robinson and Torvik (2005) cannot explain overinvestment that does not lead to a negative surplus. Indeed, while Robinson and Torvik (2005) present a very plausible theory to explain white elephants, their theory cannot explain the construction of projects like Ghana’s recent multi-million dollar and controversial presidential palace[8] which was constructed in the capital, Accra, an ethnically diverse and metropolitan city in the Greater Accra region of the country. It is hard to believe that the NPP government’s goal was to use the project to transfer resources to its political supporters given that its strongholds are in the Ashanti and Eastern regions of the country. Third, I show that even if investment is used

[8] See a report by BBC on Ghana’s presidential palace at: http://news.bbc.co.uk/2/hi/africa/7720653.stm

as a transfer to induce cooperation, whether there is overinvestment depends on the nature of transfers.

The seminal models of entry deterrence by Dixit (1980) and Spence (1977) also predict overinvestment. To the extent that an incumbent firm has to overinvest because it has incomplete property rights over market power, such models are related to the idea in this paper. A difference is that, unlike this paper, the investment undertaken by the incumbent firm does not have any positive value to the entrant. Therefore, investment is not used to make transfers to the entrant and so does not facilitate cooperation in the sense of this paper.

The reminder of the paper is organized as follows: the next section considers a single-period two-stage model of investment and contest over property rights with complete information. Section 3 considers an infinitely-repeated version of the model in section 2. Section 4 discusses the results and section 5 concludes the paper.

2. Investment and property rights

Consider a variant of the model of investment in the absence of complete property rights in Konrad (2002). [9] There are two risk-neutral agents, 1 and 2. Agent 1 owns an asset (e.g., a piece of land). Agent 2 is an encroacher who derives utility from using the

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[9] Although the basic model in this section is similar to Konrad (2002), my results and focus in this paper differ from his. First, Konrad (2002) restricts his analysis to the case where the asset owner and the encroacher have the same valuation of the asset. He introduces asymmetry between the players by giving the owner a head-start advantage in his success probability; that is, the owner has some positive probability of success even if his effort is zero and the thief exerts a positive effort. Konrad (2002) is primarily interested in this head-start advantage as the title of his paper indicates. Second, and most importantly, the analyses in section 3 of this paper is different from Konrad (2002).

asset. Let V = V(x) be the value of an asset to the owner when he invests x dollars in the asset. Assume that $x \geq 0$, $V(0) = 0$, $V'(x) > 0$ and $V''(x) < 0$. Let W = W(x) be the value of the asset to the encroacher, where $W(0) = 0$ and $W'(x) > 0$. Different valuations of the asset may be due to different abilities of the agents. For example, suppose when x is invested in the asset, it gives an intermediate input, n(x), which is used in a final production function $f_j(n(x))$, where $V(x) = f_1(n(x))$ and $W(x)= f_2(n(x))$, j = 1,2.

2.1 Complete property rights

Consider the benchmark case of complete property rights. In this case, the owner's first-best level of x is

$x^* = \arg\max V(x) - x$,

where x^* satisfies $V'(x^*) = 1$.

2.2 Incomplete property rights with complete information

Now consider the case of incomplete property rights. Suppose the owner invests e_1 dollars in protecting his property and the encroacher invests e_2 dollars to challenge the property rights of the owner.

Assume that the probability that the owner will successfully protect his asset is $p_1 = \frac{e_1}{e_1 + e_2}$. Accordingly, the probability that the encroacher will be successful is $p_2 = 1 - p_1$. This is an all-or-nothing, winner-takes-all contest. However, we can also interpret these probabilities as the proportions of the asset that each person can control or use.

The probability function above is known as the contest success function and the particular form used here is referred to as an imperfectly-discriminating contest success function because the party with the higher effort does not win with certainty. When the party with the higher effort wins with certainty, the contest is perfectly discriminating and is referred to as an all-pay auction (e.g., see Konrad, 2009). I return to this distinction in section 4.

I model the game as a two-stage game. In the first stage the owner chooses x and in the second stage, the encroacher and owner choose e_1 and e_2 simultaneously in a complete-information contest. I look for a subgame perfect equilibrium by backward induction.

Working backwards, consider stage 2. In this stage, noting that x is sunk, the players' payoffs are

$$U_1 = p_1V(x) - e_1 \quad (1)$$

and

$$U_2 = p_2W(x) - e_2 \quad (2)$$

The unique pure-strategy Nash equilibrium values, after some algebra, are

$\hat{e}_1 = \dfrac{V^2W}{(V+W)^2}$ and $\hat{e}_2 = \dfrac{W^2V}{(V+W)^2}$ (see, for example, Nti, 1999; Konrad, 2009). The equilibrium probability for the owner is $\hat{p}_1 = \dfrac{V}{V+W}$. The owner's payoff is

$U_1^N = \dfrac{V^3}{(V+W)^2} > 0$ and the encroacher's payoff is $U_2^N = \dfrac{W^3}{(V+W)^2} > 0$. Note that for any x, 0 < $\hat{p}_1$ < 1. I suppress the dependence of W and V on x for notational convenience whenever necessary.

In stage 1, the owner chooses x to maximize

$$S_1(x) = \frac{V^3}{(V+W)^2} - x, \tag{3}$$

Taking the derivative of (3) with respect to x and evaluating at x* noting that $V'(x^*) = 1$ and simplifying gives

$$\left.\frac{\partial S_1}{\partial x}\right|_{x=x^*} = \frac{-2V^3W'(x^*) - 3VW^2 - W^3}{(V+W)^3} < 0 \tag{4}$$

Let $\hat{x}$ = arg max $S_1(x)$. This is the asset-owner's optimal level of investment when property rights are incomplete.[10] Then (4) implies that $\hat{x}$ < x*. Hence there is underinvestment when property rights are incomplete.

The underinvestment result holds if the contest is an all-pay auction. The proof is straightforward. Suppose V(x) > W(x) for all x. Then, as shown by Hillman and Riley (1989) and Baye et al. (1996), the owner's expected payoff in a mixed-strategy equilibrium in the contest is V(x) − W(x). Therefore, he will choose x to maximize V(x) − W(x) − x. Then given $W'(x) > 0$, it is easy to show that the owner will choose x < x*. If V(x) ≤ W(x) for all x, then the owner's equilibrium payoff in the contest is zero. Therefore, his optimal investment is zero.[11]

The analysis gives the following proposition:

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[10] I assume that the second-order condition for a local maximum holds. If W(x) = βV(x), then $S_1(x) = V(x)/(1+\beta) - x$, where β is a positive parameter. Clearly, in this case, the optimal investment is an interior solution and is a unique global maximum.

[11] Note that even if V(x) > W(x) for all or V(x) ≤ W(x) for all x does not hold, the underinvestment result will still hold because in stage 1, the asset owner knows that any x chosen will give a payoff of either zero or V(x) – W(x) in stage 2.

Proposition 1: *In the subgame perfect equilibrium of the finite-period investment-cum-contest game the owner's level of investment in the asset when property rights are incomplete will be smaller than his level of investment when property rights are complete.*

Proposition 1 is robust to changing the timing of moves in the contest or the use of the generalized Tullock contest success function (e.g., see Konrad (2009) for a discussion of this function). It is consistent with the results of Allen (2002), Konrad (2002), Gonzalez (2005) and the other papers cited in section 1.[12]

3. Infinitely-repeated interaction and incomplete property rights

Consider an infinitely-repeated version of the model in section 2. Without loss of generality, suppose W(x) = V(x). In *each* period, the asset owner makes an investment choice and then possibly engages in a contest with the encroacher. I shall show that there can be overinvestment in this environment.

Suppose the encroacher and the asset owner decide to negotiate a self-enforcing peaceful agreement. In each period, the asset owner will give the encroacher an upfront transfer. In return, the encroacher will not challenge the property rights of the asset owner. Since in the benchmark game in section 2, the asset owner chooses his investment before the contest over property rights, I maintain consistency in the timing of moves by assuming that the asset owner chooses his investment before the parties bargain over the size of the transfer.

[12] Proposition 1 also holds if investment and effort decisions are made simultaneously. To make a different point, suppose V(0) = W(0) > 0. This may be the case because the asset (e.g., a piece of land for grazing) may have value even if it is not maintained. Then if W(x) rises sufficiently faster than V(x), we can show that the asset owner will choose x = 0 even if investment is costless. That is, $S_1(0) > S_1(x) + x$ for x > 0.

Suppose that the asset owner can commit to an agreement but the encroacher cannot. Commitment by the asset owner is plausible because he has to honor his side of the agreement first (i.e., make an upfront transfer to the encroacher) before the encroacher honors his side of the agreement. In other words, the asset owner cannot betray the encroacher in any period. This is also the case in Greif (1993, 1994) where merchants cannot cheat but their agents can. Hence, in Greif (1993, 1994), only the merchants have a punishment strategy and he refers to this as a one-sided prisoner's dilemma game in Grief (1994). In my case, only the asset owner has a punishment strategy.

The asset owner uses a Nash reversion strategy (trigger strategy) where he punishes the encroacher by reverting to the Nash equilibrium play forever if the encroacher reneges on the agreement.[13] Let $\delta \in [0,1)$ be the encroacher's discount factor.

The timing of actions is as follows. In each period:

(i) The asset owner chooses the level of investment, x,

(ii) The asset owner and the encroacher bargain over the size of a transfer from the asset owner to the encroacher.

(iii) If they agree on the transfer, the asset owner gives the transfer to the encroacher and the encroacher agrees not to challenge the property rights of the asset owner. And if the encroacher does not renege, the game ends and the sequence of actions

[13]For a recent and interesting analysis using a Nash reversion strategy, see Conconi and Sahuguet (2009). It is well known that the strategies in Abreu (1986, 1988) can sustain cooperation in cases where a Nash reversion strategy fails to do so. However, using a Nash reversion strategy is sufficient to prove that there could be overinvestment. As will be shown below, what matters is not the value of the critical discount factor but whether it is decreasing in the level of investment.

is repeated in the next period.[14] If the encroacher reneges, the equilibrium of the stage game is played forever in subsequent periods.

(iv) If there is no agreement in (iii), there is a contest over control of the asset.

Thereafter, we are back to (i) and the sequence of actions is repeated in the next period.

3.1 Equilibrium analysis

I want to construct a cooperative (no-conflict) subgame perfect equilibrium, so I solve the game backwards beginning in stage (iii) in the sequence of actions such that the parties agree on a transfer and the encroacher does not renege.

Let the transfer from the asset owner to the encroacher be $S_2^C = \Omega$ in each period. Then the asset owner gets $S_1^C = V(x) - \Omega - x$. For each party to participate in a cooperative arrangement we require the following necessary conditions:

$$S_2^C \geq U_2^N(\hat{x}) \equiv S_2^N \tag{5}$$

and

$$S_1^C \geq S_1^N \equiv U_1^N(\hat{x}) - \hat{x}\,, \tag{6}$$

where S_1^N and S_2^N are the players' equilibrium payoffs in the stage game.

If the encroacher reneges on the agreement, he will expend a positive but small effort, ε, in the contest and, given the contests success function, appropriate the entire asset with certainty (i.e., $p_2 = 1$ if $e_2 > 0$ and $e_1 = 0$). So the encroacher's payoff, if he

[14] Of course, after several periods of successful bargaining agreements, a norm will develop under which there is no further need to bargain and the parties simply use the transfer rule used in previous periods. However, since bargaining is costless in my model, it really does not matter whether they bargain in every period.

deviates, is $S_2^D = V(x) - \varepsilon + \Omega$ in the current period.[15] In all subsequent periods, both players revert to the Nash equilibrium of the stage game, where in each period, the asset owner gets $S_1^N(\hat{x}) = 0.25V(\hat{x}) - \hat{x}$ and the encroacher gets $S_2^N = 0.25V(\hat{x})$. Using well-known arguments, it can easily be shown that given that the asset owner uses a Nash reversion strategy, the encroacher will not deviate in any period if

$$\delta \geq \frac{S_2^D - S_2^C}{S_2^D - S_2^N} = \frac{V(x)}{V(x) + \Omega - 0.25V(\hat{x})} \equiv \hat{\delta}(x), \qquad (7)$$

where the expression on the RHS is the limiting case as $\varepsilon \to 0$.

Case (a): Encroacher has no bargaining power

In this case, the asset owner can make a take-it-or-leave-it offer to the encroacher. Consider an equilibrium with cooperation. Since we require $\hat{\delta}$ < 1 for (7) to hold, it follows that (5) must hold with strict inequality. Therefore, a necessary condition for cooperation is $\Omega > 0.25V(\hat{x})$. Next, note that if $\Omega > 0.25V(\hat{x})$, then $\hat{\delta}$ is increasing in x. Therefore, if (13) holds for some x > x*, then it will necessarily hold for any x ≤ x*. Finally, x* = arg max [$S_1^C = V(x) - \Omega - x$]. Hence if there is cooperation the asset owner will choose x ≤ x* and if there is no cooperation, he will choose $\hat{x}$ < x*. Therefore, overinvestment is not possible.[16]

[15] I assume that the encroacher does not invest in the asset because he does not have the power to take investment decisions. This is consistent with the subsequent example of political patronage discussed below. Therefore, if the encroacher deviates and fully acquires the asset and uses it, the asset owner thereafter has to decide how much to invest in it in the next period. Given his Nash reversion strategy, he will choose the non-cooperative level of investment forever.

[16] Another way of proving this result is by contradiction. Consider a cooperative equilibrium with overinvestment. The asset owner can *maintain* the size of the lump-sum transfer at the same level and maximize his surplus at x*. This will still ensure cooperation because V(x*) is smaller than V(x) for x > x*. Given that the size of the transfer is still the same, if the encroacher reneges he will get V(x*) + Ω which is

Case (b): Encroacher has some bargaining power

Suppose instead that the encroacher and asset owner bargain over the size of the transfer. The bargaining game can be captured by the maximization of the generalized Nash bargaining product,

$$M = [V(x) - \Omega - U_1^N(x)]^{\theta}[\Omega - U_2^N(x)]^{1-\theta},$$

where $0 < \theta < 1$, x has already been chosen to determine V(x), and M is strictly concave in **Ω**. [17] Then the optimal transfer solves $\partial M/\partial\Omega = 0$ and is given by $\boldsymbol{\Omega^*} = \eta V(x)$, where $\eta \equiv 0.75 - 0.5\theta \in (0.25, 0.75)$ given $0 < \theta < 1$. In this case, the transfer is a fixed proportion, η, of the value of the asset. Therefore, if the encroacher has some bargaining power, the transfer will be an increasing function of the investment in the asset.

Then $S_1^C = V(x) - \eta V(x) - x$ and (7) becomes

$$\delta \geq \frac{V(x)}{(1+\eta)V(x) - 0.25V(\hat{x})} \equiv \underline{\delta}(x) \quad (8)$$

smaller than V(x) + Ω if x > x*, so given that the encroacher does not deviate at x > x*, he would also not deviate from cooperation if he is given the same transfer and x* is the level of investment.

[17] Note that since x is sunk, the asset owner's threat point in the bargaining game does not include the cost of investment. It is simply his payoff in the contest. Therefore bargaining, as in Anbarci et al. (2002), takes place in the shadow of conflict. However, notice that the asset owner's individual rationality constraint in (6) is his payoff in the contest less the cost of investment. This is because to construct an equilibrium in which he cooperates in every period, he has to be guaranteed his payoff in the non-cooperative equilibrium. The same argument applies to the encroacher.

In this case, $\underline{\delta}$ is decreasing in x. [18] Then to sustain cooperation, it may be desirable to make $\underline{\delta}$ sufficiently small by choosing $\bar{x} > x^*$ and also satisfy the individual rationality constraints in (5) and (6).

To demonstrate the preceding point, let $\tilde{x}$ be the asset owner optimal level of x in a cooperative equilibrium. Define x** = arg max$[S_1^C = V(x) - \eta V(x) - x]$. Note that x** < x* given $V'(x) > 0$. Suppose $\bar{x}$ satisfies (8) with strict equality. Then $\bar{x} = \underline{\delta}^{-1}(\delta)$ and any $x < \bar{x}$ violates (8) while any $x \geq \bar{x}$ satisfies (8). Therefore, a necessary condition for overinvestment is $\bar{x} > x^*$. Given that S_1^C is maximized at x**, the asset owner will like to choose x as close as possible to x** while satisfying (5), (6), and (8). Therefore, if $\bar{x} > x^* > x^{**}$ and (5) and (6) are also satisfied at $\bar{x}$, then the optimal investment is $\tilde{x} = \bar{x} = \underline{\delta}^{-1}(\delta) > x^*$. Indeed, since (8) is satisfied at $\bar{x}$, this implies that $\underline{\delta}(\bar{x}) < 1$ and therefore $\eta V(\bar{x}) > 0.25V(\hat{x})$ and, for that matter, (5) is also satisfied.

If the assumptions of the preceding paragraph hold, then we know that $\partial\tilde{x}/\partial\delta < 0$. Therefore, the more patient the encroacher is, the less is the asset owner's level of investment in the cooperative equilibrium. Note that we can write $\underline{\delta}(\tilde{x}, \eta) = \delta$, where the LHS is decreasing in η using (8). Then given that $\underline{\delta}$ is also decreasing in x, it follows that when cooperation is sustained, an increase in η leads to a fall in $\tilde{x}$.

As an example, consider $\eta = 0.3$, $\delta = 0.8006$, and $W(x) = V(x) = 2x^{0.5}$. Then $x^* = 1$, $\hat{x} = 0.0625$, $S_1^N = 0.0625$, and $S_2^N = 0.125$. Let the asset owner choose $\tilde{x} = 1.5 > x^*$. Then $S_1^C = 0.2146$, $S_2^C = 0.7348$, and $\underline{\delta}(\tilde{x}) = 0.8006$. Clearly, $S_1^C > S_1^N$ and

[18] When x = 0, the critical discount factor in (8) is equal to zero which suggests that cooperation can be sustained. But this cannot be possible because given V(0) = 0, the constraint in (6) is violated. Hence, (8) and, for that matter, (7) are defined for x > 0.

$S_2^C > S_2^N$. Note that $\underline{\delta}(x) > 0.8006$ for $x \in (0, \tilde{x})$. It is easy to verify that any x > $\tilde{x}$ = 1.5 gives a lower value of $S_1^C = V(x) - \eta V(x) - x$ than at x = $\tilde{x}$. Therefore, given δ = $\underline{\delta}(\tilde{x})$ = 0.8006, there is a subgame perfect equilibrium with overinvestment where the optimal investment is $\tilde{x}$ = 1.5 > x* = 1.

Note that while overinvestment can be used to induce cooperation, it is not necessarily the case that cooperation requires overinvestment. It is possible to construct a cooperative equilibrium with underinvestment, even if the transfer depends on investment. However, overinvestment can only occur in a cooperative equilibrium while underinvestment can occur in either a cooperative or a non-cooperative equilibrium. Therefore, in the model, a cooperative equilibrium is necessary for overinvestment while it is not for underinvestment.

An important remark is in order. Notice that the asset owner could have chosen x* and given the encroacher a lump-sum transfer of $\tilde{\Omega} = \eta V(\tilde{x})$. This would give $\delta = \underline{\delta}(\tilde{x}) > \hat{\delta}(x^*)$, make the asset owner better off, and make the encroacher no worse off, where using (7) and (8)

$$\hat{\delta}(x^*) = \frac{V(x^*)}{V(x^*) + \eta V(\tilde{x}) - 0.25V(\hat{x})}, \tag{7a}$$

$$\underline{\delta}(\tilde{x}) = \frac{V(\tilde{x})}{V(\tilde{x}) + \eta V(\tilde{x}) - 0.25V(\hat{x})}, \tag{8a}$$

and

$$\eta V(\tilde{x}) \equiv \tilde{\Omega} > 0.25V(\hat{x}).$$

By breaking the link between the transfer to the encroacher and investment, it is clear that overinvestment is not possible. Therefore, to restore the overinvestment result we need to argue that breaking the link between the transfer and investment is not possible. Notice that by arguing that the asset owner could have given the encroacher a lump-sum transfer of $\tilde{\Omega} = \eta V(\tilde{x})$, we were making the implicit assumption that we were back to the case where the asset owner could make a take-it-or-leave-it offer. Yet, if the asset owner had this power, he will not choose $\tilde{\Omega} = \eta V(\tilde{x})$. To see this, note that given $\delta = \underline{\delta}(\tilde{x}) > \hat{\delta}(x^*)$, the asset owner can sustain cooperation at x* and increase his payoff by choosing a transfer $\Omega^{**} < \tilde{\Omega} = \eta V(\tilde{x})$ and still satisfy $\delta = \underline{\delta}(\tilde{x}) \geq \hat{\delta}(x^*)$ and $\Omega^{**} > 0.25V(\hat{x})$. This means that the encroacher will be worse off. This means that the encroacher will prefer that the $\eta V(x)$ transfer rule is follow or will use his bargaining power. Therefore, the overinvestment result still holds.

It is important to note that I am not arguing that {x*, $\tilde{\Omega}$} is not feasible or will not satisfy the parties' individual rationality constraints. My argument is that given $\delta = \underline{\delta}(\tilde{x}) > \hat{\delta}(x^*)$, if the asset owner can make a take-it-or-leave-it offer, then there exists a pair {x*, Ω^{**}} that strictly dominates {x*, $\tilde{\Omega}$} for the asset owner and satisfies the encroacher's individual rationality constraints, where $\Omega^{**} < \tilde{\Omega}$.

Even if one were to argue that the encroacher can simply ask the asset owner to give him $\tilde{\Omega} = \eta V(\tilde{x})$, nothing prevents the asset owner from making a counter offer which is less than $\tilde{\Omega}$. Once we appreciate the incentive to make these offers and counter offers, we are back to the process of bargaining.[19] Therefore, if we accept that bargaining is what determines the size of the transfer then we have to stick to the $\eta V(x)$ transfer rule.

[19] Note that Nash bargaining that is used here can be derived from a Rubinstein-style alternating-offers bargaining game (Binmore, Rubinstein, and Wolinsky, 1986).

To argue otherwise is to argue that somehow the asset owner can make a take-it-or-leave-it offer.

3.2 Other equilibria

It is well known that supergames have multiple equilibria. In particular, even *without transfers*, any symmetric effort,[20] $e^c \in [0, \tilde{e}]$ can be sustained as a subgame perfect equilibrium, where each player exerts an effort of $e_1 = e_2 = e^c$ in the contest, and given $V(x) = W(x)$, $\tilde{e} = 0.25V(x)$ is the Nash equilibrium effort of the stage game *given* an investment of x. In this case, the asset owner's per period equilibrium payoff is $\tilde{S}_1^C = 0.5V(x) - x - e^c > 0.25V(\hat{x}) - \hat{x}$ and the encroacher's per-period equilibrium payoff is $\tilde{S}_2^C = 0.5V(x) - e^c > 0.25V(\hat{x})$.

In this case, the asset owner can renege on the effort level e^c that is tacitly agreed upon. In what follows, I assume that the asset owner can commit to an agreement. Since I shall later argue that the scheme with bargaining and transfers makes more sense than this tacit coordination case, this assumption is innocuous. Besides, one can easily allow the encroacher to also use a Nash reversion strategy which will induce the asset owner to stick to the tacitly agreed upon effort of e^c (see footnote 23).

When $e^c > 0$, the conflict success function is well defined with $p_1 = p_2 = 0.5$. So it makes sense to assume that each party gets 50% of the value of the asset based on the outcome of the conflict for symmetric effort. When $e^c = 0$, the contest success function is undefined. In this case, I do not assume that the encroacher gets 0.5V(x) in equilibrium. Consistent with my previous analysis, I instead assume that the encroacher, through

[20] Without loss of generality, I restrict the analysis to symmetric values of effort. There are also equilibria with asymmetric effort.

costless bargaining, gets $\eta V(x)$ which also allows for the possibility of $\eta = 0.5$. To elaborate, I assume that an equilibrium without conflict (i.e., $e^c = 0$) is only achieved through bargaining which determines the transfer from the asset owner to the encroacher. On the other hand, if the parties "tacitly" coordinate on an equilibrium with conflict (i.e., $e^c > 0$), then bargaining, by definition, is off the table and they instead resort to conflict to determine the division of V(x). I shall elaborate on this below.

Putting $e^c > 0$ into the encroacher's best-response function, we know that if the encroacher deviates, he will choose $e_2^d = \sqrt{e^c V(x)} - e^c$. So when he deviates, his payoff will be $\tilde{S}_2^D = \frac{e_2^d}{e_2^d + e^c} V(x) - e_2^d = V(x) - 2\sqrt{e^c V(x)} + e^c$. Then there is a subgame prefect equilibrium with $e^c \in (0, \tilde{e}]$ if[21]

$$\delta \geq \frac{\tilde{S}_2^D - \tilde{S}_2^C}{\tilde{S}_2^D - S_2^N} = \frac{0.5V(x) - 2(\sqrt{e^c V(x)} - e^c)}{V(x) - (2\sqrt{e^c V(x)} - e^c) - 0.25V(\hat{x})} \equiv \tilde{\delta}(x)\,. \tag{9}$$

Then

$$\text{sign}\frac{\partial \tilde{\delta}}{\partial x} = \text{sign}[0.5 - \tilde{\delta} - (1 - \tilde{\delta})\sqrt{e^c / V(x)}]\,. \tag{10}$$

Suppose $e^c = \tilde{e}$. Then $\tilde{\delta}(x) = 0$ since $\tilde{S}_2^d - S_2^C = 0$ because $e_2^d = \sqrt{\tilde{e}V(x)} - \tilde{e} = \tilde{e} =$ 0.25V(x). Hence $\partial\tilde{\delta}/\partial x = 0$ at $e^c = \tilde{e}$. It is easy to show that $\partial\tilde{\delta}/\partial x < 0$ at $e^c = 0$. Since $\partial\tilde{\delta}/\partial x$ is continuous in e^c, it follows that $\partial\tilde{\delta}/\partial x < 0$ for any $e^c \in (0, \bar{e})$, where

[21] When $\eta = 0$, the expression in (8) does not boil down to the expression in (9) with $e^c = 0$ because the expression in (8) was based on the assumption that the encroacher's per-period payoff when $e^c = 0$ is equal to the transfer, while for (9) the encroachers gets 0.5V(x) in addition to the transfer. Therefore, based on my assumptions, the inequality in (9) only makes economic sense in an equilibrium when $e^c > 0$.

$0 < \bar{e} \leq \tilde{e}$.[22] Given that the critical discount factor is decreasing in x, we can construct an equilibrium without transfers but with conflict (i.e., $e^c > 0$) and overinvestment.[23] Therefore, the multiplicity of equilibria and the absence of bargaining/transfers do not change my main

result. [24]

Therefore, even if there is an equilibrium with conflict, there could still be overinvestment since the critical discount factor, $\tilde{\delta}(x)$, is decreasing in x. The important thing to note is that in either the no-conflict or conflict case, the encroacher's equilibrium payoff (i.e., $\eta V(x)$ or $0.5V(x) - e^c$) is increasing in x. This is necessary for the critical discount factor to be inversely related to the level of investment.

So will the parties choose bargaining or conflict? Parties that want to resolve conflicts do not typically negotiate on a limited but positive level of conflict (i.e., $e^c > 0$). They typically negotiate for peace (no conflict) and use transfers to induce peaceful behavior.[25] Indeed, given that I assume that bargaining is an option and since bargaining obviously involves explicit communication, if the parties are going to cooperate at all,

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22 If $\partial\tilde{\delta}/\partial x$ is monotonic in e^c, then $\bar{e} = \tilde{e}$. Otherwise, this may not be the case.

23 For example, suppose $V(x) = W(x) = 2x^{0.2}$. Then x* = 0.3181. There is an equilibrium with conflict and a unique investment level $x = \tilde{x} = 0.4 > x^*$ if $e^c = 0.1$, and $\delta = \tilde{\delta}(0.4)$. The asset owner's per-period payoff is 0.3325 and the encroacher's per-period payoff is 0.7325. The corresponding payoffs in the stage game are 0.2249 and 0.2811 respectively. Note that given the investment level of 0.4, each player will exert an effort of $\tilde{e} = 0.25V(0.4) = 0.4167 > e^c = 0.1$.

24 In this case, the asset owner can deviate from equilibrium by exerting an effort greater than e^c. So the analysis assumes that asset owner can commit to e^c. However, allowing the encroacher to also use a Nash reversion strategy and noting that $S_1^N = 0.25V(\hat{x}) - \hat{x}$, the analogue of (9) for the asset owner can be derived by simply subtracting $\hat{x}$ from the denominator of (9). Hence, the asset owner's critical discount factor is higher than the encroacher's critical discount factor. This is because $S_1^N = 0.25V(\hat{x}) - \hat{x} < S_2^N = 0.25V(\hat{x})$, so the cost of punishment is smaller for the asset owner. However, his critical discount factor is also decreasing in x.

25 Of course, actual bargaining need not be costless, as assumed in my model.

then a peaceful equilibrium supported by transfers and the credible threat of punishment makes sense. Being a small number of people, the parties in this case are unlikely to engage in some kind of tacit coordination that might lead to $e^c > 0$. Commenting on Schelling's famous idea of a focal point with reference to his example of people who had planned to meet in New York but forgotten to say where, Farrell and Rabin (1996, p. 112) echo this view when they observed that "[A]lthough Schelling's work remains fascinating … we find this emphasis on tacit coordination surprising, because we think that people in small-numbers coordination problems usually can and will talk." The example of political transfers discussed below in section 4 is consistent with this scenario. Therefore, my contention is that case of bargaining and a no-conflict outcome supported by transfers is a more plausible scenario.

It should be obvious by now that what is generally required for the overinvestment result is that the transfer must be an increasing function of investment. Bargaining is one mechanism that produces this result but as shown above it is not necessary mechanism. Another mechanism is a requirement that the transfer must be an in-kind transfer. For example, if the asset-owner can only compensate the encroacher by transferring a proportion of the asset after investment has taken place, then the transfer will also be an increasing function of investment. I describe another application in section 3.3.

To sum up, if the encroacher has some bargaining power over how the returns from the asset should be shared or, more generally, if the transfer is increasing in the level of investment, then overinvestment is possible. This gives the following proposition:

Proposition 2: *If the encroacher has some bargaining power over the size of the transfer from the asset owner to him or, more generally, if the transfer is increasing in the level of investment, then in the in finite-period investment-cum-contest game, it is possible to construct subgame perfect equilibria with cooperation in which the owner's level of investment in the asset when property rights are incomplete is greater than his level of investment when property rights are complete.*

In section 1, I elaborated on the intuition for the overinvestment result in proposition 2. So I will not rehash it here. The reader may refer to the argument in section 1.

3.3 Further remarks

A requirement that the transfer must be linked to the proceeds of a public project could make the transfer an increasing function of investment. Such transfers may be desirable when there are institutional constraints on the nature of transfers from the asset owner to the encroacher. For example, consider a politician who can only make transfers to those who challenge his authority by investing in pork-barrel and then bargain with them over the proceeds of the project in each period. [26] This will be consistent with the logic of political survival and patronage that is documented and discussed in De Mesquita et al. (2003). Indeed, as Coate and Morris (1995) show, it may be optimal for politicians to choose inefficient forms of transfers like in-kind transfers via public projects in order

[26] It is important to note that the politician considers the investment in the pork-barrel project as a cost although he is financing it from public coffers. When Konrad (2002) applies his model to the behavior of autocrats he implicitly assumes that the politician takes the cost of investment into account. A reason why the politician may take the cost into account may be due to the moral and expected material cost of wrongdoing. For example, this makes sense if his punishment should he be out of power (e.g., by people other than his cronies) and convicted of corruption is increasing in x. Or as in Robinson and Torvik (2005), he may take this cost into account simply because every dollar spent has an opportunity cost. An example may be the distortionary cost of taxes used to finance the project.

to disguise transfers to special interests.[27] Established norms of corruption may require that the politician gets a share, $1 - \eta$, of the proceeds of the public project while his challengers get the rest. This is consistent with the commonly-held belief that kickbacks in corrupt deals are computed as some fixed proportion of government projects or contracts.[28] This may be the case because the value of the contract varies, so paying a fixed lump-sum may not make sense. However, having been a practice established over several years, it is not unreasonable to expect that this practice may still remain even if the value of contracts is expected to be constant.[29]

In some cases, the politician's main motivation may not be to make transfers to special interests. Again, suppose institutional constraints compel the politician to have surrogates who run public projects and give him his agreed-upon *share* of the proceeds of the public project. Therefore, the politician's investment decision in the project is driven by his own pecuniary motives. For example if this is a democracy with term limits and the politician is in his last term, then the nature of his transfer and investment decision are not driven by the fear of losing power. These decisions are instead driven by the fear of being prosecuted after his tenure in office.[30] This is what induces him to choose less transparent forms of transfers like public projects. Then reneging on the agreement means that his surrogates take all the proceeds from the project in a given period. The politician

[27] Of course, there is a well-known literature which argues that in the presence of moral hazard and adverse selection, in-kind transfers may be efficient.
[28] For example, Aslund (2008) mentions allegations of kickbacks of 20% to 50% on major infrastructure projects in Russia.
[29] This is analogous to the persistence of sharecropping contracts in rural and developing countries (see, for example, Allen and Lueck, 1992).
[30] Technically, though, the term limit makes the interaction between the politician and his surrogates a finitely-repeated game. However, in a democracy without term limits or in an autocracy (as in the previous example), cooperation could still be sustained if the politician is re-elected or stays in power with an exogenous probability (see Conconi and Sahuguet, 2009, Dal Bo, 2005). This means that the last period is not known with certainty. And in my model, the critical discount factor will still be decreasing in x with such an exogenous probability of staying in power. This is what is required to get the overinvestment result.

who has the exclusive right on how much should be invested in each period will then revert to the non-cooperative level of investment which, in this case, could be the minimal level of level of investment in the project. The politician and his surrogates will get nothing or a very small payoff relative to the payoff in the cooperative equilibrium.[31] As in the previous case, the politician has incomplete economic rights over the project.

In the above example, one may argue that when the politician's challengers deviate they get $S_2^D = \eta V(x) + (1-\eta)V(x) = V(x)$ not $S_2^D = (1+\eta)V(x)$. Then the critical discount factor is $\overline{\delta}(x) = (1-\eta)V(x)/[V(x) - S_2^N]$. However, it is still possible to construct equilibria with overinvestment. This is because the crucial condition that the critical discount factor, $\overline{\delta}(x)$, is decreasing in x still holds.

4. Further discussion of results

The argument that overinvestment facilitates cooperation by increasing the transfer to the encroacher will not be applicable to the example of the overinvestment undertaken by squatters discussed in section 1. However, as discussed in section 3.3, it is consistent with the use of public projects by politicians as transfers aimed at holding on to political power in autocracies and democracies or as a way of transferring resources to themselves.

Unlike Robinson and Torvik (2005), it is not crucial for my result that the project must yield a negative social surplus for the politician to invest in it. In my model, the private benefit to the politician, $(1 - \eta)V(x)$ must be sufficiently greater than the cost, x

[31] Generally, what matters for the analysis is that the one-period payoff from deviating from the cooperative equilibrium outweighs the payoff in the cooperative equilibrium which, in turn, outweighs the payoff in the Nash equilibrium.

(i.e., $S_1^C \geq S_1^N$) . Therefore, in an equilibrium with overinvestment, $V(\tilde{x}) - \tilde{x}$ is sufficiently greater than zero. Hence, the politician may overinvest in the project even if he takes the cost into account. However, given that the interest of the rest of society is ignored, this situation may be consistent with either a negative social surplus. Therefore, my analysis is not inconsistent with the construction of white elephants (i.e., projects with negative social surplus).[32] However, because the asset-owner in my model (i.e., the politician in this case) does not *deliberately* invest in a project with a negative social surplus, I cannot claim that my model explains the phenomenon of white elephants in Robinson and Torvik (2005).

In the case of an all-pay auction, we showed that the asset owner's investment is zero if the encroacher has a higher valuation than the asset owner. This zero investment is consistent with Smith's (2002) condition that for a high valued asset to exist in the public domain (i.e., a neglected, ill-maintained asset which tends to be common property) the encroacher must value the asset more at high values than does the owner. While Smith's (2002) intuition is correct, I have shown that his conclusion also depends on the nature of competition over property rights.

While the analysis leading to proposition 1 demonstrates that there is underinvestment in both the imperfectly discriminating contest and all-pay auction, the fact that investment in the all-pay auction is necessarily zero when the encroacher has a higher valuation but is positive when the contest is imperfectly discriminating deserves a further remark in terms of the intuition behind this difference in results. If the competition over property rights is extremely sensitive to the efforts of the contestants

[32] Of course, if the politician and his cronies are included in social welfare, then social surplus is necessarily positive in my model.

(e.g., all-pay auction), the battle over property rights is more likely to be very fierce. In addition, if the encroacher is stronger (i.e., has a higher valuation), then the asset owner has the incentive to minimize this extremely fierce battle by significantly reducing the value of the asset.

5. Conclusion

Contrary to standard results in the recent literature on investment and property rights, I have shown it is possible for an asset-owner to overinvest in the asset when property rights are incomplete. As noted in the introduction, the idea that transfers or redistribution can be used to induce cooperation, when property rights are incomplete, is not new. The new result here is that the nature of transfers can lead to overinvestment.

The result of this paper does not necessarily mean that incomplete property rights are desirable because they boost investment. Like underinvestment, overinvestment also leads to a welfare loss relative to the first-best case of complete property rights. The goal of social policy ought to be the enhancement of property rights taking into account the cost of establishing such enhanced property rights. Of course, I do not mean the enhancement of the property rights of corrupt politicians.

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