Can Foreign Aid Buy Investment? Appropriation Through Conflict*

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ABSTRACT: The failure of foreign aid to promote growth in the developing world has received significant attention as evidence suggests that foreign aid does not translate into investment. This research has demonstrated that poor institutions in these developing economies (particularly with respect to property rights) results in an inability to fully appropriate the return to one's investment, thereby serving as a prominent disincentive to investment. This paper presents an experimental test of a a 2-player, one-shot game of conflict in which we vary the strength of property rights. Our results suggest that stronger property rights reduce conflict and increase investment. In addition, we test the conventional wisdom that technological progress can increase the effectiveness of aid in stimulating investment. Contrary to intuition, we find technological progress has practically no effect on investment and that this failure to stimulate investment is largely due to deficiencies in property right institutions.

KEYWORDS: Property Rights; Conflict; Investment; Foreign Aid; Experiments

JEL CLASSIFICATIONS: C72; C91; F35; O12; O43; P48

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1 Introduction

Can foreign aid buy growth? This question was posed by Easterly (2003) in response to the evidence presented by Burnside and Dollar (2000) suggesting that foreign aid promotes growth in the presence of good institutions. The result is intuitively appealing: Good institutions create a healthy environment for investment and investment translates into growth. However, empirical investigations into the relationship between aid, institutions and growth have generated mixed results (Hansen and Tarp, 2001; Dalgaard and Hansen, 2001; Guillamont and Chauvet, 2001; Lensink and White, 2001; Collier and Dollar, 2002; Easterly et al., 2004; Collier and Hoeffler, 2004). Indeed, it is not clear that aid translates into investment *or* investment translates into growth (Easterly, 1999). Understanding the relationship between resource allocation (e.g., foreign aid) and investment in the face of imperfect institutions is therefore the logical starting point to answering the question posed by Easterly (2003). That is, in order to determine if foreign aid can buy growth, it must first be established under what circumstances can foreign aid yield investment.

In principal, there are two reasons why foreign aid will not be invested: either the marginal cost of consumption is greater than the rate of return on investment or there is a problem with appropriation. The problem of appropriation is one of the most prominent disincentives to investment in the literature (Demsetz, 1967; Alchian and Demsetz, 1973; North, 1987; Murphy et al., 1993; Shleifer and Vishny, 1993; Mauro, 1995; Hall and Jones, 1999; Easterly, 2001; Alesina and Weder, 2002; Gradstein, 2004; Gonzalez, 2007; Gonzalez and Neary, 2008; Gradstein, 2007). One manner in which the appropriation problem can manifest itself is in the form of corruption (Shleifer and Vishny, 1993; Mauro, 1995; Easterly, 2001; Alesina and Weder, 2002). Corruption acts as a tax on investment, and, like a tax, reduces the incentive to invest (Shleifer and Vishny, 1993).[1] Alternately, appropriation may be manifest through imperfect institutions, particularly those involving property rights. Recent growth models have formalized this problem, demonstrating how imperfect property rights result in the appropriation of

[1] Unlike tax revenues, it is unlikely that bribes are used for public good provision.

investment returns occurs through costly conflict (Gradstein, 2004; Gonzalez, 2007; Gradstein, 2007; Gonzalez and Neary, 2008).[2] This in turn reduces the incentives to invest, suggesting that secure property rights are a necessary condition for aid to translate into increased invesmtent.

Whether its called corruption, conflict, or rent-seeking (Tullock, 1980), a lack of well-defined property rights results in resources being diverted from investment into appropriation activities (Demsetz, 1967; Alchian and Demsetz, 1973). This problem represents a variation on the classic prisoner's dilemma: A deficiency of property rights simultaneously creates an incentive to protect one's own investment and to steal someone else's. Unlike the prisoner's dilemma, the conflict game promises hope; as property rights are increased, the return from appropriative activities and the need to defend one's invesmtents necessarily fall. This inturn increases the resources and incentives to invesmtment.

Beyond the effect of property rights, Easterly (2001) and others have argued that the rate of return on investment may be too low to induce investment suggesting that aid should be accompanied with subsidized technological progress. On one hand, conventional wisdom suggests increasing the overall productivity of the economy raises the return to investment, and thus the opportunity cost of conflict. In this case, technological progress compliments the effect of property rights, raising the effectiveness of foreign aid.[3] On the other hand, increasing the return on investment also raises the return to conflict by increasing the return to investment and thus the soils of appropriating another's invesmtent. In this case, an increase in productivity offsets the effect of property rights, lowering the effectiveness of foreign aid. As such, "an increase in overall economic productivity leaves the proportionate allocation of resources between producing and fighting unchanged" (Hirshleifer, 1991, p. 184). That is, the increased incentive to invest and the increased incentive to engage in expropriation are completely offset. Hence, raising the rate of return on investment, contrary to intuition, may have no effect on the equilibrium level of investment.

[2]These papers are part of a larger literature on conflict (Haavelmo, 1954; Garfinkel, 1990; Grossman, 1991, 1994; Grossman and Kim, 1995; Hirshleifer, 1989, 1991, 1995; Skaperdas, 1992, 1996; Gradstein, 2004; Gonzalez, 2007; Gradstein, 2007; Gonzalez and Neary, 2008; Schudel, 2008).

[3]We use effectiveness here to mean the fraction of aid that is invested.

In this paper, we present the results of an experimental test of behavior in a 2-player, one-shot game of conflict.[4] Specifically, we explore how allocation decisions vary in response to exogenous variations in property rights and the productivity of investment (e.g., the level of technology). Our experiment explores the effects of two levels of property rights and two levels of technology, resulting in a 2 x 2 design which we implement in a within-subjects design wherein all subjects are exposed to all combinations of treatment parameter. The strength of such a design is its ability to eliminate confounding subject-specific effects, since these are constant across treatments. Furthermore, our design allows for the identification of causal effects of property rights and technological progress on conflict and investment, since we observe responses to exogenous changes in treatment parameters. These benefits permit us to gain insights that are less readily gained through direct empirical research. For example, Besley (1995) stresses the problem of endogeneity of property rights in traditional empirical investigations. In the laboratory we present a controlled setting in which we study the mechanics of conflict in hope of shedding light on the failure of aid to translate into investment (Easterly, 2001).

Following Grossman and Kim (1995) and Gonzalez (2007) we assume individuals allocate resources (e.g., foreign aid) among (i) a productive investment generating consumable goods, (ii) defensive appropriation which appropriates one's own return on investment, (iii) offensive expropriation which expropriates another individual's return on investment, and (iv) direct (i.e., safe) consumption. The model distinguishes between offensive expropriation and defensive appropriation in order to incorporate property rights into the conflict technology. The conflict technology, or "contest success function" (Hirshleifer, 1989; Skaperdas, 1996), plays an integral role as it translates allocations into relative appropriations. Property rights determine the effectiveness of allocations to defensive appropriation relative to offensive expropriation. Thus, property rights strengthen ones claim to ownership and reduce incentives to divert resources to offensive and defensive appropriation activities.

[4]This paper extends the experimental literature (Carter and Anderton, 2001; Duffy and Kim, 2005; Durham et al., 1998) of conflict games being the first to explicitly test the ability of property rights to reduce conflict and increase investment.

In general, we find support for the predictions regarding property rights and technology. In our experiment subjects reduce allocations to conflict in response to stronger property rights. However, this effect is not symmetric. While offensive allocations decrease in response to stronger property rights, the resources allocated to defensive activities remains unchanged. The reduction in offensive appropriation however translates almost entirely into increased investment. Perhaps more importantly, we find no reduction in appropriative activities in response to improvements in productivity. This demonstrates the importance of property rights in creating an environment in which aid can yield investment (and in turn growth). Without improvements in property rights, improvements in technology fail to yield increased investment. Thus our results highlight the importance of addressing institutional issues (e.g., property right regimes) when considering the effects of allocating aid.

The paper is organized as follows. Section 2 presents a model of conflict based on that of Gonzalez (2007) from which we motivate our hypotheses. Section 3 describes the experimental design and formal hypotheses. In section 4 we present the results from our analysis of subject choices. Finally, we summarize and discuss the results in section 5.

2 A Game of Conflict

Following the models developed by Grossman and Kim (1995), Gonzalez (2007), and Gonzalez and Neary (2008), we examine the optimal allocation of foreign aid under imperfect property rights. We assume agents are endowed with aid and must choose how to allocate these resources among competing economic activities. Specifically, we assume that aid can be allocated to investment in productive activities that produce consumable goods, appropriation of this investment, expropriation of someone else's investment, or the aid can be exchanged for an equivalent amount of consumable goods. As such, we first derive the symmetric Nash equilibrium allocations to consumption, investment, defensive appropriation and offensive expropriation. We then examine the comparative statics of the model to derive predictions of

the response of Nash equilibrium allocations to exogenous changes in property rights and productivity. As in the cited literature, property rights are modeled as determining the relative strength of defensive appropriation relative to offensive expropriation and productivity is simply the rate of return on investment. In what follows, we will demonstrate that increasing the overall productivity of the economy initially increases investment through reductions in consumption, however, beyond a point, it has no effect. By contrast, strengthening of property rights is predicted to converge Nash equilibrium allocations towards Pareto optimality.

For simplicity, consider a game between two agents, i and j. Each agent is assumed to have an equal endowment of resources (e.g., equal shares of foreign aid) E. Agents can allocate their aid to an investment, k_i, with an exogenous rate of return A. However, the return on the investment Ak_i is not secure since property rights are not well-defined. Resources may be allocated to defensive appropriation x_i in order to secure the return on the investment. Likewise, aid may also be allocated to offensive expropriation z_i to steal the other agents' investment returns. Finally, agent's may choose not to allocate aid at all; they may consume it, c_i. Thus, each agent faces the following budget constraint:

$$E_i = c_i + k_i + x_i + z_i. \tag{1}$$

The role of property rights is to determine the effectiveness of defensive appropriation relative to offensive expropriation; property rights strengthen an agent's claim to ownership. We denote by p_i the fraction of agent i's return which she appropriates. We denote by q_i the fraction of agent j's return which is appropriated by agent i (i.e., the amount expropriated by agent i). We characterize these shares as follows:

$$p_i = \frac{\pi x_i^m}{\pi x_i^m + z_j^m}, \tag{2}$$

$$q_i = \frac{z_i^m}{\pi x_j^+ z_j^m}. \tag{3}$$

where m is the "decisiveness factor" (Hirshleifer, 1995) and π captures the strength of property rights.[5] This characterization of property rights captures the notion that property rights strengthen ones claim of ownership, but the claim still has to be made. Since property rights are imperfect ($\pi < \infty$), conflict arises as agents struggle to appropriate the return on their investment while expropriate that of others.[6] Thus, agent i does not receive his entire return if $z_j > 0$. However, stronger property rights increases the fraction of his return agent i receives for a particular allocation (i.e. $\frac{\partial p_i}{\partial \pi} > 0$). Likewise, stronger property rights decreases the fraction of j's return i receives for a particular allocation (i.e. $\frac{\partial q_i}{\partial \pi} < 0$).

Each agent i seeks to maximize the sum of their consumption and appropriated returns:

$$\max_{x_i,z_i,k_i,c_i} U_i = c_i + p_i A k_i + q_i A k_j, \tag{4}$$

subject to equation (1). Substituting equations (1), (2), and (3) into equation (4), the objective function for agent i may be written as:

$$\max_{x_i,z_i,c_i} U_i = c_i + A\left(\frac{\pi x_i}{\pi x_i + z_j}\right)(E_i - c_i - x_i - z_i) + A\left(\frac{z_i}{\pi x_j + z_j}\right)(E_j - c_j - x_j - z_j). \tag{5}$$

The Kuhn-Tucker condition with respect to consumption is:

$$\frac{\partial U_i}{\partial c_i} = 1 - A\frac{\pi x_i}{\pi x_i + z_j} \leq 0, \quad c_i^* \geq 0, \quad c_i^* \frac{\partial y_i}{\partial c_i} = 0. \tag{6}$$

Equation (6) indicates that for interior solutions in x_i and z_i, a sufficiently large rate of return on investment A and property rights π optimal consumption is a corner solution. That is, the optimal solution is to allocate the entire endowment and consume nothing, $E = k_i^* + x_i^* + z_i^*$ and $c_i^* = 0$.[7] In contrast, under sufficiently weak property rights and low rates of return on

[5] The decisiveness factor, m, is set equal to 1 for the purpose of the experiment. Durham et al. (1998) conduct an experiment with exogenous variation in m to test whether fighting intensifies with higher levels of the decisiveness factor. Their results suggest conflict intensifies with the decisiveness factor.

[6] It is assumed that $p_i = 1$ if $x_i = z_j = 0$ and $q_i = 1$ whenever $x_j = 0$ and $z_i > 0$.

[7] The experiment is parameterized such that this condition is satisfied in the symmetric equilibrium.

investment, optimal consumption is again a corner solution: agents should consume their entire endowment $c_i^* = E$.

Assuming an interior solution, the first order condition with respect to x_i is:

$$\frac{\partial U_i}{\partial x_i} = -Ap_i + A(E_i - x_i - z_i)\frac{\partial p_i}{\partial x_i} = 0.$$

Substituting for p_i and $\frac{\partial p_i}{\partial x_i}$ yields:

$$\frac{\partial U_i}{\partial x_i} = -A\frac{\pi x_i}{(\pi x_i + z_j)} + A(E_i - x_i - z_i)\frac{\pi z_j}{(\pi x_i + z_j)^2} = 0. \tag{7}$$

Assuming an interior solution, the first order condition with respect to z_i is:

$$\frac{\partial U_i}{\partial z_i} = -Ap_i + A(E_j - x_j - z_j)\frac{\partial q_i}{\partial z_i} = 0.$$

Substituting for p_i and $\frac{\partial q_i}{\partial x_i}$ yields:

$$\frac{\partial U_i}{\partial z_i} = -A\frac{\pi x_i}{\pi x_i + z_j} + A(E_j - x_j - z_j)\frac{\pi x_j}{(\pi x_j + z_i)^2} = 0. \tag{8}$$

The term $-Ap_i$ in equations (7) and (8) represents the marginal opportunity cost of appropriative activities, the forgone marginal *appropriated* return on investment. The second terms represent the marginal benefit of increased appropriation. Thus, agents tradeoff higher returns for more appropriation. Furthermore, since the marginal costs of the two appropriative activities are the same, in equilibrium the agents will equate the marginal benefits of appropriative activities. Equations (7) and (8) combined implicitly define the optimal level of investment $k_i^* = k_i(\pi) = E_i - x_i^* - z_i^*$. By imposing symmetry, we can explicitly define the optimal levels of appropriation, expropriation and investment respectively as:

$$x_i^* = x_j^* = \frac{1}{\pi + 3}E, \tag{9}$$

$$z_i^* = z_j^* = \frac{1}{\pi+3}E, \tag{10}$$

$$k_i^* = k_j^* = \frac{(\pi+1)}{\pi+3}E. \tag{11}$$

We now turn our attention to the effect of exogenous changes in the rate of return on investment and on the strength of property rights. Both the optimal level of defensive activity, x_i^*, and offensive activity, z_i^*, are independent of the rate of return on investment:

$$\frac{\partial x_i^*}{\partial A} = 0, \tag{12}$$

$$\frac{\partial z_i^*}{\partial A} = 0. \tag{13}$$

This is due to the assumption of a common production technology. In the symmetric Nash equilibrium agents equate the marginal benefits of offensive and defensive activities. Since the agents' investments earn equivalent rates of return, changing the rate of return will not effect the equilibrium allocations. Thus, in contrast to conventional wisdom, increasing the rate of return on investment has no effect on investment,[8]

$$\frac{\partial k_i^*}{\partial A} = -\frac{\partial x_i^*}{\partial A} - \frac{\partial z_i^*}{\partial A} = 0. \tag{14}$$

However, both appropriation and expropriation (i.e. conflict) are decreasing in the level of property rights.

$$\frac{\partial x_i^*}{\partial \pi} = \frac{-E}{(\pi+3)^2} < 0 \tag{15}$$

$$\frac{\partial z_i^*}{\partial \pi} = \frac{-E}{(\pi+3)^2} < 0 \tag{16}$$

Thus, *only* increasing property rights is predicted to increases the resources allocated to invest-

[8] In an alternate model in which investment or consumption were not corner solutions, this would not be the case when $\pi = \infty$.

ment.

$$\frac{\partial k_i^*}{\partial \pi} = -\frac{\partial x_i^*}{\partial \pi} - \frac{\partial z_i^*}{\partial \pi} = \frac{2}{(\pi+3)^2}E > 0 \tag{17}$$

3 Experimental Design and Hypotheses

In this section we present our experimental design and motivate our hypotheses based on the model above. The experiment implements all the elements of the theory to investigate the effects of technological progress and property rights on investment and conflict. In each decision period subjects are randomly paired with another subject (the *other person*) in the session.[9] Every subject was given an *endowment* of \$10 lab to allocate among an *investment*, appropriation of his investment (*defensive spending*), expropriation of the investment of the other person (*offensive spending*), or direct consumption. The amount a subject allocates to the investment is increased by a multiplier (rate of return on investment). The amount a subject allocates to *defensive spending* increases the fraction of his own investment he retains provided the other person allocates something to *offensive spending*.[10] The amount a subject allocates to *offensive spending* increases the fraction of the other person's investment that he appropriates for herself. These shares were based on the characterizations in equations (2) and (3) with $m = 1$. Any endowment that is not allocated the subject retains and is added to his earnings for the period (i.e. representing her direct consumption).

We implement a 2 x 2 within-subjects design, varying the return on investment (i.e. A in the model, the investment multiplier) and property rights (i.e. π in the model, the effectiveness of *defensive spending* relative to *offensive spending*). The investment multiplier was either 3 or 5 and and *defensive spending* is either 2 or 4 times as productive as *offensive spending*.[11] This results in 4 treatments as summarized in Table 1 along with the symmetric Nash equilib-

[9] Italics are used throughout this section to indicate the exact terminology used in the experiment. Randomized pairing is intended to minimize reciprocity. Durham et al. (1998) investigate the effect of fixed pairs relative to random pairs and find the random pairs induces less cooperative behavior.

[10] If the other person does not allocate anything to *offensive spending* than the subject always receives his entire investment, regardless of the amount allocated to *defensive spending*.

[11] Thus, *defensive spending* is always more effective than *offensive spending*.

rium predicted values for *investment*, *defense*, and *offense* as a percentage of the *endowment*. Subjects are randomly assigned to a treatment in each decision period.

Table 1: **Experimental Design**

Treatment $\{A,\pi\}$	Predicted (%) Investment	Predicted (%) Conflict	Predicted (%) Defense	Predicted (%) Offense
T1 = $\{3,2\}$	60	40	20	20
T2 = $\{5,2\}$	60	40	20	20
T3 = $\{3,4\}$	70	30	15	15
T4 = $\{5,4\}$	70	30	15	15

Based on the model in section 2, we present the following hypotheses. Our first hypotheses concern the effect of property rights on conflict and investment, where conflict is defined to be the sum of the allocations to *defense* and *offense* spending. Let conflict and investment be defined, respectively, as

$$Conflict = \beta_{\mathbf{A}\pi}\mathbf{D}_{\mathbf{A}\pi} + \beta_{\mathbf{t}}\mathbf{R}_{\mathbf{t}} + \beta_{\mathbf{P}}\mathbf{P}_{\mathbf{i}} + \varepsilon_{ijt}, \tag{18}$$

and

$$Investment = \beta_{\mathbf{A}\pi}\mathbf{D}_{\mathbf{A}\pi} + \beta_{\mathbf{t}}\mathbf{R}_{\mathbf{t}} + \beta_{\mathbf{P}}\mathbf{P}_{\mathbf{i}} + \varepsilon_{ijt}. \tag{19}$$

where $\mathbf{D_{ij}}$ is a vector of treatment dummy variables where A denotes the rate of return on investment and π denotes the level of property rights, $\mathbf{R_t}$ is a vector of round fixed-effects, $\mathbf{P_i}$ is a vector of player fixed-effects, and ε^1_{ijt} is the unobserved error.[12] According to equations (15) and (16), appropriation and expropriation are decreasing in the level of property rights. Therefore, we should observe a decrease in conflict from T1 to T3 and from T2 to T4.

Hypothesis 1 $\beta_{3,2} > \beta_{3,4}$ *and* $\beta_{5,2} > \beta_{5,4}$: *An increase in property rights should result in a decrease in conflict, ceteris paribus.*

According to equation (17), investment is increasing in property rights. Therefore, we should observe an increase in investment from T1 to T3 and from T2 to T4.

[12]One of the strengths of a within-subjects design is that the player fixed-effects should be uncorrelated with the treatments, allowing for a cleaner test of treatment effects.

Hypothesis 2 $\beta_{3,2} < \beta_{3,4}$ *and* $\beta_{5,2} < \beta_{5,4}$: *An increase in property rights should result in an increase in investment, ceteris paribus.*

The next two hypotheses concern the rate of return on investment on conflict and investment. According to equations (12) and (13), appropriation and expropriation are unaffected by the rate of return on investment. Therefore, we should observe an no difference in conflict between T1 and T2 nor from T3 to T4.

Hypothesis 3 $\beta_{3,2} = \beta_{5,2}$ *and* $\beta_{3,4} = \beta_{5,4}$: *An increase in the rate of return on investment should result in no change in conflict.*

According to equations 14, investment is unaffected by the rate of return. Therefore, we should observe an no difference in investment between T1 and T2 but we should observe an increase in investment from T3 to T4.

Hypothesis 4 $\beta_{3,2} = \beta_{5,2}$ *and* $\beta_{3,4} = \beta_{5,4}$: *An increase in the rate of return on investment should result in no change in investment.*

The experimental sessions consisted of 5 practice periods (for no money) and 20 decision periods. Prior to making any decisions, subjects were presented with instructions on the computer screen which they proceed through as the moderator read aloud. Screen images are available upon request from the authors. Additionally, subjects were given aids intended to decrease the cognitive burden of the decision (Smith and Walker, 1993). Subjects were provided with two sets of tables on a sheet of paper which they retained throughout the experiment. The first tables gave the fraction of a subject's investment they appropriated based on their allocation to *defensive spending* and the other person's allocation to *offensive spending*. The second tables gave the fraction of the other person's investment they expropriated based on their allocation to *offensive spending* and the other person's allocation to *defensive spending*. The decision screen required subjects to enter not only their allocation but also their conjecture of the other person's allocation (see Figure 1). Based on their entries, the subject was shown both her own and the

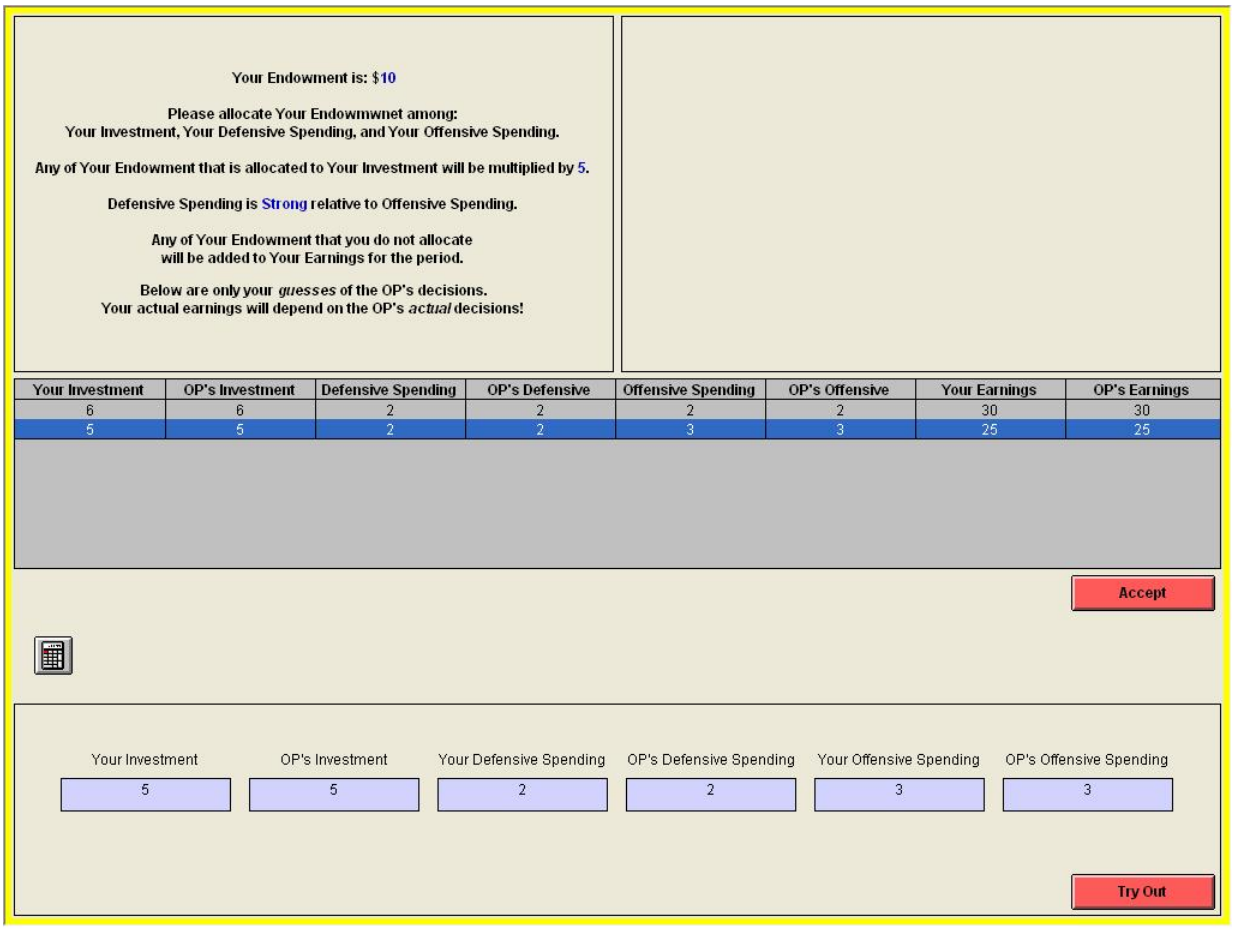

Figure 1: Decision Screen

other person's hypothetical earnings for the period. This served as a profit calculator for participants in which the subject could enter as many allocation and conjecture combinations as desired, selecting one of these combinations to be implemented as their decision in the round. Subjects had ninety seconds to make the allocation decision.[13]

Upon completion of the decision task subjects were shown a summary screen showing their earnings for the period and information from all periods. In order to maintain the static, single period nature of the theory, 1 period is randomly selected for payment at the end of the experiment. After the last period was completed a screen revealed the selected period to the subjects in a session. After viewing this screen, subjects were asked a series of debriefing

[13]If a subject failed to choose an allocation after ninety seconds, they retained their endowment (i.e. they consumed their entire endowment).

questions and paid for their participation in private.

The experiment was conducted in the University of Calgary Behavioral and Experimental Economics Laboratory (CBEEL) with subjects recruited via the lab's Online Recruitment System for Experimental Economics (Greiner, 2004). The experiment is programmed and conducted with the software Z-Tree (Fischbacher, 2007). Experimental sessions last approximately 90 minutes and average earnings were $17 including a $5 show-up fee.

4 Analysis of Results

4.1 Analysis of Conflict Choices

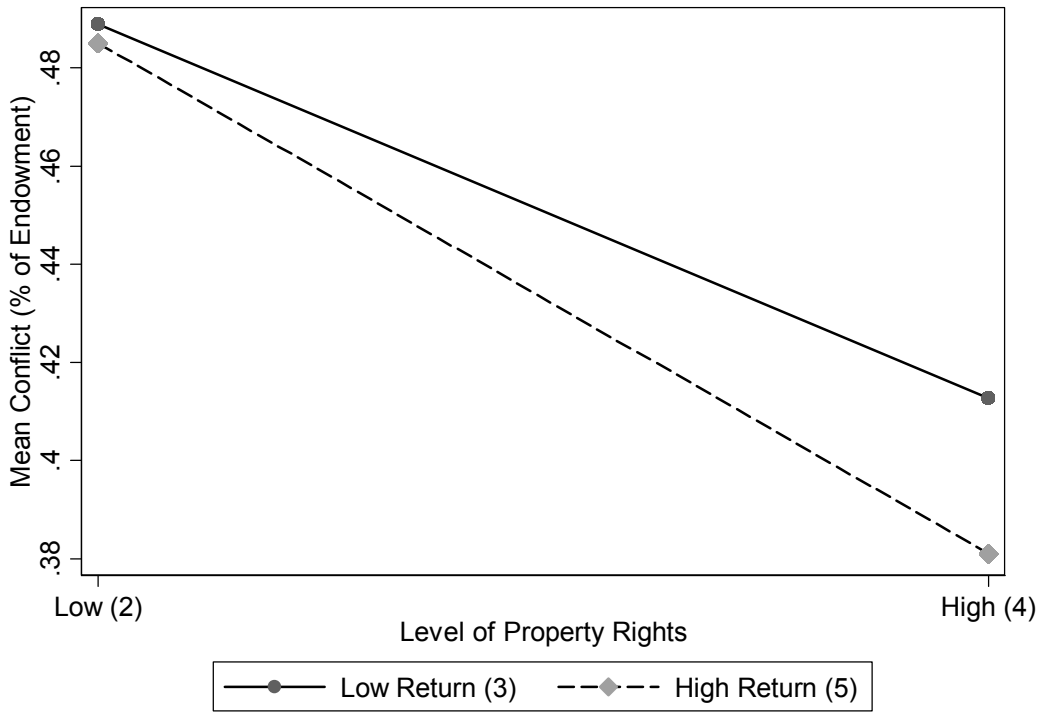

Figure 2: **Mean Conflict per Treatment**

We begin the analysis of our results by examining the effects of the treatment variables on observed levels of conflict. Recall, conflict is defined to be the sum of the allocations made

Table 2: **Mean Conflict per Treatment as a Percentage of Endowment**

	Property Rights		
Return on Investment	**Low** ($\pi = 2$)	**High** ($\pi = 4$)	**Test Statistic**
Low ($A = 3$)	0.489	0.413	$z = 4.961$
	(0.194)	(0.168)	$Prob > z = 0.000$
High ($A = 5$)	0.485	0.381	$z = 7.557$
	(0.182)	(0.159)	$Prob > z = 0.000$
Test Statistic	$z = 0.404$	$z = 2.384$	
	$Prob > z = 0.686$	$Prob > z = 0.017$	

Notes: The Table reports sample means and standard errors in parentheses. The test statistics and p-values are reported in the margins for the various two sample tests.

to defensive and offensive spending. Figure 2 plots the level of conflict across the levels of property rights for both the low and high returns on investment. According to hypothesis 1, conflict should be decreasing in property rights. The figure demonstrates this is clearly the case. Table 2 reports the mean levels of conflict as a percentage of the endowment and the results of Wilcoxon rank-sum tests. For either level of the return on investment the mean level of conflict is lower when property rights is higher and the difference is significant at the 1% level. To demonstrate the economic significance, increasing property rights from $\pi = 2$ to $\pi = 4$ decreases mean conflict from 46% to 37% of the endowment. This represents a 20% reduction in the fraction of resources allocated to conflict.

According to hypothesis 3, the rate of return on investment should not have an effect on the level of conflict. However, Table 2 reports an 8.0% reduction in conflict when the level of property rights was high, which is statistically significant. We observe no such change when property rights were low. Thus, the results for hypothesis 3 are mixed.

Examination of the contingent components of conflict, defensive and offensive spending, reveals the source of the inconsistency from theoretical predictions. Figure 3 plots the level of offensive and defensive spending across the levels of property rights for both the low and high returns on investment. Note that there is a reduction in offensive spending as property rights improve, but the rate of return on investment has no effect. Table 3 indicates that the

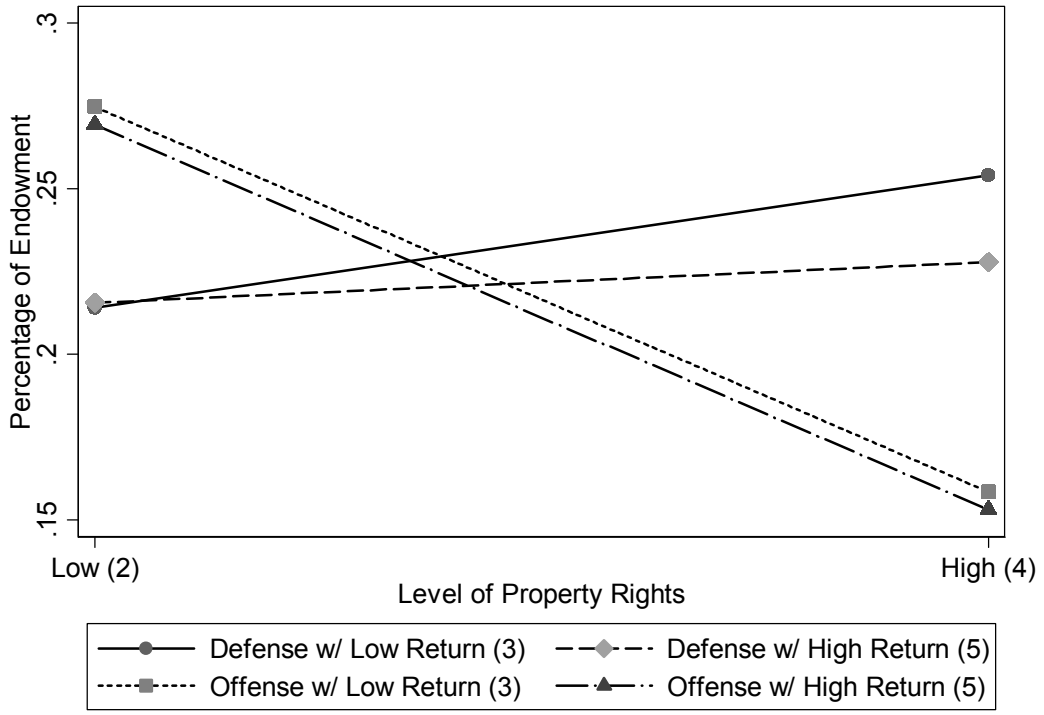

Figure 3: **Mean Offensive Spending and Mean Defensive Spending per Treatment**

Table 3: **Mean Offensive Spending per Treatment as a Percentage of Endowment**

	Property Rights		
Return on Investment	**Low** ($\pi = 2$)	**High** ($\pi = 4$)	**Test Statistic**
Low ($A = 3$)	0.275	0.158	$z = 7.982$
	(0.203)	(0.127)	$Prob > z = 0.000$
High ($A = 5$)	0.269	0.153	$z = 8.977$
	(0.204)	(0.131)	$Prob > z = 0.000$
Test Statistic	$z = 0.445$	$z = 0.699$	
	$Prob > z = 0.656$	$Prob > z = 0.484$	

Notes: See notes Table 2.

effect of property rights is statistically significant for changes in offensive spending. Thus, the inconsistency between observed behavior and theoretical predictions resides in defensive spending. There is relatively no difference in defensive spending across treatments. Table 4 shows that there are statistically significant effects.

All of the hypothesis tests above assume the samples to be independent, which is clearly

Table 4: **Mean Defensive Spending per Treatment as a Percentage of Endowment**

	Property Rights		
Return on Investment	**Low** ($\pi = 2$)	**High** ($\pi = 4$)	**Test Statistic**
Low ($A = 3$)	0.214	0.254	$z = -3.169$
	(0.100)	(0.128)	$Prob > z = 0.002$
High ($A = 5$)	0.216	0.228	$z = -0.766$
	(0.103)	(0.108)	$Prob > z = 0.444$
Test Statistic	$z = 0.002$	$z = 2.519$	
	$Prob > z = 0.998$	$Prob > z = 0.012$	

Notes: See notes Table 2.

Table 5: Linear Regression Results for Conflict.

	(1)	(2)
Treatment $\{3,2\}$	4.89***	4.14***
	(0.21)	(0.055)
Treatment $\{5,2\}$	4.85***	4.07***
	(0.19)	(0.055)
Treatment $\{3,4\}$	4.13***	3.20***
	(0.19)	(0.23)
Treatment $\{5,4\}$	3.81***	3.11***
	(0.19)	(0.22)
Subject Effects	No	Yes
Period Effects	No	Yes
R^2	0.865	0.926

Notes: The dataset consists of a panel of 58 subjects over 20 decision periods (1130 observations). Errors are clustered by subject. Standard errors are reported in parentheses. Statistical significance of the estimated coefficients: "*" significant at the 10% level, "**"significant at the 5% level, and "***"significant at the 1% level.

not the case given the within-subjects design. We now analyze the level of conflict controlling for subject-specific and period-specific effects. Table 5 reports the regression results for linear models estimated via ordinary least squares. Model (1) includes only the treatment dummy variables. Model (2) adds subject and round fixed-effects. The results from the panel models are consistent with the results from the pooled regression. Table 6 reports the results of formal hypothesis tests on the regression coefficients. The results of the hypothesis tests in Table 6 are summarized below.

Table 6: Hypothesis Test Results for Conflict.

	Hypothesis	(1)	(2)
1:	$H_O : \beta_{3,4} - \beta_{3,2} \geq 0$	-3.60	-4.73
	$H_A : \beta_{3,4} - \beta_{3,2} < 0$	(0.00)	(0.00)
1:	$H_O : \beta_{5,4} - \beta_{5,2} \geq 0$	-5.26	-5.19
	$H_A : \beta_{5,4} - \beta_{5,2} < 0$	(0.00)	(0.00)
2:	$H_O : 1 - \beta_{3,2} - \beta_{5,2} = 0$	0.23	0.68
	$H_A : 1 - \beta_{3,2} - \beta_{5,2} \neq 0$	(0.41)	(0.41)
2:	$H_O : 1 - \beta_{3,4} - \beta_{5,4} = 0$	2.32	0.98
	$H_A : 1 - \beta_{4,4} - \beta_{5,4} \neq 0$	(0.01)	(0.17)
	Subject Fixed-Effects	N.A.	69872.69
			(0.00)
	Round Fixed-Effects	N.A.	1.32
			(0.20)

Notes: Columns correspond to the models estimated in Table 5. The numbered hypothesis tests report the t-statistic. The subject and period effects are F-statistics. The numbers in parentheses are the p-values. "N.A." means not applicable.

Result 1 *Four out of four tests reject the hypothesis that stronger property rights do not decrease conflict. Thus we find strong support for hypothesis 1.*

Result 2 *Three out of four tests fail to reject the hypothesis that technological progress does not decrease conflict. Thus we find weak support for hypothesis 3.*

4.2 Analysis of Investment Choices

We now examine the effect of our treatment variables on average investment. Recall that subjects could retain their endowment; subjects had the option of *not* allocating some or all of their endowment. However, over all treatments subjects allocated their entire endowment among the three activities 92.5% of the time. Thus, the effects on investment mirror those of conflict. According to hypothesis 2, investment should increase with increased property rights. Figure 4 demonstrates that increasing property rights results in an increase in observed mean investment for either rate of return on investment. For the high return on the investment ($A = 5$), increasing property rights results in an increase in investment from 51.5% to 61.3% of the

Figure 4: **Mean Investment per Treatment**

endowment. This represents a 19% increase in the fraction of resource allocated to investment. Note that since participants were allocating all of their endowments, Figure 3 suggests that the observed increase in investment is attributable solely to the reductions in offensive spending which accompany improvements in property rights. That is, rather than poor property rights resulting in individuals consuming their resources directly, our results suggest that offensive spending in the face of relatively weak property rights crowds out investment. Table 7 reports mean levels of investment as a percentage of the endowment for each treatment and reports the results of Wilcoxon rank-sum tests. The table demonstrates that the effect of increased property rights is statistically significant at the 1% level. According to hypothesis 4, investment should be unaffected by increasing the rate of return on investment. The table suggests while this is true for relatively weak property rights, there is a statistically significant increase in investment for relatively strong property rights (although the economic significance is not all that great; only a 6% increase in the fraction of resources allocated).

Table 7: **Mean Investment per Treatment as a Percentage of Endowment**

	Property Rights		
Return on Investment	**Low** ($\pi = 2$)	**High** ($\pi = 4$)	**Test Statistic**
Low ($A = 3$)	0.493	0.573	$z = -5.117$
	(0.203)	(0.188)	$Prob > z = 0.000$
High ($A = 5$)	0.506	0.608	$z = -7.300$
	(0.184)	(0.172)	$Prob > z = 0.000$
Test Statistic	$z = -0.829$	$z = -2.309$	
	$Prob > z = 0.407$	$Prob > z = 0.021$	

Notes: See notes Table 2.

Table 8: Linear Regression Results for Investment.

	(1)	(2)
Treatment $\{3,2\}$	4.93***	4.14***
	(0.22)	(0.055)
Treatment $\{5,2\}$	5.06***	4.07***
	(0.20)	(0.055)
Treatment $\{3,4\}$	5.73***	3.20***
	(0.22)	(0.23)
Treatment $\{5,4\}$	6.08***	3.11***
	(0.21)	(0.22)
Subject Effects	No	Yes
Period Effects	No	Yes
R^2	0.865	0.926

Notes: See notes Table 5.

Again, the hypothesis tests above assume the samples to be independent, which is not the case. As such, we analyze the level of investment controlling for subject-specific and period-specific effects. Table 8 reports the regression results for linear probability models estimated via ordinary least squares. Model (1) includes only the treatment dummy variables. Model (2) adds subject and round fixed-effects. The results from the panel models are consistent with the results from the pooled regression. Table 9 reports the results of formal hypothesis tests on the regression coefficients. The results of the hypothesis tests in Table 9 are summarized below.

Table 9: Hypothesis Test Results for Investment.

	Hypothesis	(1)	(2)
1:	$H_O : \beta_{3,4} - \beta_{3,2} \leq 0$	3.51	4.73
	$H_A : \beta_{3,4} - \beta_{3,2} > 0$	(0.00)	(0.00)
1:	$H_O : \beta_{5,4} - \beta_{5,2} \leq 0$	5.03	5.19
	$H_A : \beta_{5,4} - \beta_{5,2} > 0$	(0.00)	(0.00)
2:	$H_O : 1 - \beta_{3,2} - \beta_{5,2} = 0$	0.80	0.68
	$H_A : 1 - \beta_{3,2} - \beta_{5,2} \neq 0$	(0.21)	(0.41)
2:	$H_O : 1 - \beta_{3,4} - \beta_{5,4} = 0$	2.38	0.95
	$H_A : 1 - \beta_{4,4} - \beta_{5,4} \neq 0$	(0.01)	(0.33)
	Subject Fixed-Effects	N.A.	1.8e+14
			(0.00)
	Round Fixed-Effects	N.A.	1.32
			(0.20)

Notes: See notes Table 6.

Result 3 *Four out of four tests reject the hypothesis that stronger property rights do not increase investment. Thus we find strong support for hypothesis 2.*

Result 4 *Three out of four tests fail to reject the hypothesis that technological progress does not increase increase. Thus we find weak support for hypothesis 4.*

5 Conclusion

This paper presents the results from a laboratory experiment examining the effect of property rights and productivity under anarchy. Under anarchy, imperfect property rights requires resources be diverted away from productive activities in order to establish "effective property rights" (Gonzalez, 2007). Distinguishing between offensive and defensive appropriation, as in Grossman and Kim (1995) and Gonzalez (2007), allows property rights to enter the conflict technology. Property rights determines the relative effectiveness of defensive to offensive appropriation. We implement a 2 x 2 experimental design with two levels of property rights and two rates of return on investment. This design allows us to investigate the effect of property rights and productivity on conflict. While property rights is predicted to reduce conflict,

increasing the rate of return on investment is predicted to have no effect on the amount of resources allocated to conflict.

As predicted, increasing property rights decreases observed conflict and increases observed investment, regardless of the return on investment. However, in contrast to the symmetric Nash equilibrium prediction, the decrease in conflict is due entirely to a decrease in offensive appropriation. Observed defensive appropriation is nondecreasing in the level of property rights. Increasing the rate of return on investment has no effect on the observed levels of offensive appropriation (at either level of property rights) or defensive appropriation (at the low level of property rights).

Our results should be interpreted as evidence of the importance of property rights in assessing the potential of foreign aid to stimulate growth. Many developing economies are plagued with institutional problems which effectively reduce the returns of all forms of investments. Our results suggest that a pre-condition for effective investment policies must be relatively secure property rights. Moreover, our results highlight an important aspect of institutional development, particularly with respect to property rights. While we observe reductions in offensive spending with improvements in property rights, we failed to observe associated reductions in defensive spending. This suggests that mere presence of imperfect property rights may create a sense of suspicion wherein offensive spending reacts immediately to institutional improvements but defensive spending lags due to remaining concerns regarding expropriation. Thus, in the dynamic context in which developing economies evolve, institutional improvements have both short term and long term benefits on the efficacy of aid. In the short term, improvements reduce the appropriative activities which crowd out investments. In the longer term, improved property rights should further increase investment by demonstrating to individuals that expropriation is less likely and thereby reduce defensive spending. This suggests that the coupling of aid with incentives to improve institutions can have significant positive effects on investment across both short and long term horizons.

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