Protection and Social Order

by

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abstract

Consider a simple world populated with two types of individuals, those who work and create wealth (peasants) and those who steal the property of others (bandits). With bandits about, peasants need to protect their output and can do so individually or collectively. But either way protection is costly; it consumes resources and interferes with an individual's ability to create wealth. This study will investigate how individuals might make decisions in such circumstances, how those decisions evolve over time, and how broader societal characteristics can emerge from such decisions.

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Protection and Social Order

Arguably, a fundamental obligation of any community is to provide protection for its citizens. But protection is not solely a public issue because individuals undertake the defense of their own property and their own rights. So, how much should one spend on self-protection, to what extent should a collective effort at protection be supported, and what resources are to be devoted to the production of all other goods in the society?

We explore these issues with a two-pronged approach. First, a simple analytical model establishes some of the basic characteristics of a group facing such decisions. We find that while agents who cooperate to collectively produce protection have higher social welfare, they may choose to not do so. Our attention then turns to the conditions under which cooperative behavior is more likely or less likely to emerge. This second issue is studied using a computational model in which autonomous agents make choices based on their own interests, but are also affected by the choices of others. Using a series of experiments in which the agents' environment becomes increasingly complex, we explore their level of cooperation and overall welfare.

While artificial, agent-based models suffer from their distant connection to reality, they also offer several useful attributes to a researcher. Highly nonlinear relationships that resist analytical tractability can be explored, researchers can focus on dynamic behavior as well as the long run or "equilibrium" characteristics of an economic system, and experiments can be repeated to study the robustness of a particular outcome (see Tesfatsion, 1997; Lane, 1993; and Axtell, 2000).

The initial model used here is inspired by a working paper by Konrad and Skaperdas (1996) and our first simulations replicate their findings. Subsequent

simulations give the agents additional choices and various opportunities to organize and in this way we extend Olsen's (1996) paper on dictators and democracy. Papers on closely related topics would include Bush and Mayer's (1974) and Hirshleifer's (1995) papers on anarchy; Grossman's (1995) study of organized crime; and Marcouiller and Young's (1995) investigation of graft. In later sections of the paper agents are allowed to move between different villages and each village sets its own level of social protection. These simulations recall Tiebout's (1956) "voting with their feet" model and points to some issues in club theory.

I. A Simple Model of Protection

Consider a simple world populated with two types of individuals: those who work and create wealth (peasants) and those who survive by taking the property of others (bandits). The presence of bandits creates an incentive for peasants to seek protection and to defend their property. Peasants can defend their output individually or join forces with others to defend themselves collectively. In either case protection is costly as it consumes resources that could otherwise be used to create wealth. Private protection is produced by the individual and has benefits that accrue solely to that individual while social protection provides benefits to all members of the society. For example, suppose protection involves standing guard or watching over your flock. In a society with only private protection each individual will watch or guard his or her own. Social or communal protection could be as simple as individuals taking turns to watch the entire group's flock.

Following the lead of Konrad and Skaperdas (1996) we standardize the production decision by assuming peasants are able to produce one unit of output per

period. Then the per-period payoff or satisfaction function for peasant *i*, s_i^p , can be written as

(1)
$$s_i^p = (x_i + \overline{y}^{\alpha})(1 - x_i - y_i)$$

where $x_i \in [0,1]$ is the amount of time spent on self protection by agent *i*; $y_i \in [0,1]$ represents the peasant's contributions to social protection; and the parameter $\alpha \in (0,1)$ reflects the technology of providing communal protection. The term

$$\overline{y} = \frac{\sum_{i=1}^{k} y_i}{k}$$
 is the average contribution to social protection by the *k* peasants in the population. Thus, peasants choose how much they wish to donate to communal protection, but regardless of that contribution they equally share its benefits.¹

Satisfaction relies on production and on protection because unprotected output is lost. But protection is costly because it consumes time (the only resource) that could alternatively be used for production. To make the problem interesting social protection is assumed to be more effective than private protection ($0 < \alpha < 1$) so that a dollar spent on social protection provides more safety than that same dollar spent on private protection.² But agents do not necessarily opt for social protection because there is an opportunity to free ride. Notice that in equation (1) if there are many peasants, an individual agent may be able to increase his payoff by eliminating his contribution to social protection all together. That would reduce his personal expenditure by y_i , but reduce his share of communal protection by only y_i/k .

¹ Collective protection technology, α , could be incorporated in other ways, e.g. multiplicatively or additively, but those alternative specifications have little effect on the basic results.

² Clearly if private protection was more effective there would be no communal protection undertaken.

With an agent's satisfaction determined by equation (1), the basic character of the model can be explored analytically.

Proposition 1:

Assuming a satisfaction function as (1) for each peasant, and a group of peasants k > 1:

(i) the aggregate level of social protection maximizing total social welfare is greater than the aggregate level selected by individual agents and;

(ii) this difference increases with k, the size of the population, and decreases with improvements in the technology of social protection, measured by α .

Proof:

Suppose this society behaves as a single entity making decisions to maximize its

collective satisfaction. Recognizing that the group's total satisfaction $S^G = \sum_{i=1}^k s_i^p$, their

contributions to self- and social protection as $X = \sum_{i=1}^{k} x_i$ and $Y = \sum_{i=1}^{k} y_i$ respectively, and

following equation (1), S^G can be written as

(1a)
$$S^G = \left[X + k\left(\frac{Y}{k}\right)^{\alpha}\right](k - X - Y).$$

The optimal levels of X and Y that maximize the aggregate satisfaction of the group are

(1*a**)
$$\begin{cases} X^* = \frac{1}{2}k\left(1 - e^{\rho} - \left(e^{\rho}\right)^{\alpha}\right) & \text{where } \rho = \frac{\ln\left(\frac{1}{\alpha}\right)}{\alpha - 1} \\ Y^* = e^{\rho}k & \text{where } \rho = \frac{\ln\left(\frac{1}{\alpha}\right)}{\alpha - 1} \end{cases}$$

These contributions, X^* and Y^* , yield maximum social welfare and correspond to the levels that would be imposed by a benevolent dictator whose goal is to maximize

aggregate satisfaction. But these are not the levels that would be chosen by independently acting agents concerned only for their personal welfare.

To see that outcome, consider the decision of a single agent who chooses his own levels of x and y to optimize his own satisfaction. Make the contributions to social protection by others exogenous to agent j by rewriting equation (1) with $\overline{y} = \frac{z + y_j}{k}$ then,

equation (1) becomes

(1b)
$$s_j^p = \left[x_j + \left(\frac{z+y_j}{k}\right)^\alpha\right](1-x_j-y_j).$$

The term $z = \sum_{i=1}^{k-1} y_i$ represents the total contributions to social protection by all

agents in the society other than agent *j*. As agent *j* considers only his own satisfaction, his optimal levels of self protection and contributions to social protection are

(1b*)
$$\begin{cases} x_j^* = \frac{1}{2} \left(1 - k e^{\tau} - (e^{\tau})^{\alpha} - z \right) \\ y_j^* = e^{\tau} k - z \end{cases}, \quad \text{where} \quad \tau = \frac{\ln\left(\frac{k}{\alpha}\right)}{\alpha - 1}.$$

The second result in $(1b^*)$ implies that the aggregate level of social contributions in this society would be $Y_j^* = e^{\tau}k$. For a society with more than one individual the difference between these two levels of aggregate contributions, *D*, to social protection is

$$D = Y_j^* - Y^* = \left(\frac{1}{\alpha}\right)^{\left(\frac{1}{\alpha-1}\right)} k - \left(\frac{k}{\alpha}\right)^{\left(\frac{1}{\alpha-1}\right)} k$$
, which is unambiguously negative, establishing

the first claim in proposition 1.

The claims in point (ii) follow directly from the derivatives,

$$\frac{\partial D}{\partial k} > 0$$
 and $\frac{\partial D}{\partial \alpha} > 0$; when $k > 1$ and $0 < \alpha < 1$.

Point (i) demonstrates the incentive of individuals to free-ride i.e., individuals will select a lower level of social contributions than is optimal for the group. The second result shows that the strength of that incentive grows with the size of the population and shrinks with an improvement in social protection technology. Thus, larger groups can expect less cooperation and consequently a lower level of aggregate welfare. That voluntary cooperation necessitates small groups is a long standing proposition in the social sciences. According to Dahl and Tuft (1973), even Plato argued that voluntary democracies will be limited in size. Extensive writings on collective behavior by Olsen (1965), Hardin (1982), and Sandler (1992) offer a similar conclusion, i.e., increasing the number of individual agents who need to cooperate in a social endeavor renders such action implausible.

It is risky to generalize from this simple outcome, but the anthropological evidence is consistent. For thousands of years most human organizations consisted of few individuals. Furthermore, as technology advanced the size of viable communities grew. Clearly there are many reasons for the parallel development of technology and the size of civilizations because technology affects many aspects of life. This simple model suggests that the ability to gain from social protection may be a contributing factor to the growth of social order.

So cooperation is potentially beneficial, but can agents identify that benefit and act to capture its gain? And, can larger groups overcome the free-riding dilemma to take advantage of the superior technology afforded by communal protection? Even in the simple model given above optimal solutions would be difficult for the average person to

discern. And when this model acquires a bit of additional complexity, such as boundedly rational agents with incomplete information, and when population size itself becomes an endogenous choice variable analytical solutions become increasingly complex and may defy resolution. Thus, the question of whether such cooperative activities can be expected to emerge becomes even more severe. To explore this issue, an agent-based, computational model is constructed and experiments are performed on those artificial populations.

II. A Computational Model of Protection:

The first task is to construct a computational model that captures the flavor of analytical model given above, but allows agents to make their decisions in a less formal manner. Thus, while we use equation (1) to calculate each peasant's satisfaction and personal decisions are based on that outcome, agents do not explicitly optimize (1).

The "threat" that necessitates protection is made internal to the analysis by formally introducing the second type of agent, a bandit. Bandits are assumed to survive by stealing the unprotected production of peasants. Following Konrad and Skaperdas (1996) we assume that all unprotected output is taken by bandits; thus, if

 $x + \overline{y} = 0$, $s_i^p = 0$. Without protection everything is lost. In general, the return to a particular bandit *i* is

(2)
$$s_i^b = \frac{\sum_{i=1}^k (1 - x_i + \overline{y}^{\alpha})(1 - x_i - y_i)}{k_b}$$

where k is the number of peasants in the population (as before) and k_b is the number of bandits. Simply put, equation (2) means bandits take all the unprotected output in society and distribute it equally among themselves. Furthermore, banditry is an occupation open

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to all agents; peasants can turn to banditry and bandits can leave their life of crime to become peasants.

A critical difference between the analytical model above and the computational model constructed here is the manner in which agents make their decisions. In section I agents explicitly optimize; here they do not. In the following numerical experiments equations (1) and (2) are used to calculate agent *i*'s satisfaction, but agents have incomplete information and limited cognitive ability. They do not "do the math" to determine their optimal contributions to private and social protection. Instead they change their behavior over time as they compare their satisfaction relative to other agents. Thus equations (1) and (2) act as "fitness" measures that drive selection.

The decision process is as follows. Agents are initially assigned a random distribution of their time: some are bandits and the rest are peasants devoting various amounts of their time to self-protection, to social protection, and to production. Using those initial values, each agent's satisfaction is calculated and ranked. The individuals who perform least well—those who are within one standard deviation of the poorest individual—consider changing their behavior. The options available are to increase or decrease self-protection, to increase or decrease contributions to social protection, to change occupations (shifting from banditry to peasantry or back), or to make no change. The particular choice is determined randomly. Once these bottom-ranked agents have made a decision every agent's satisfaction is recalculated, ranked, and once again the least fit agents consider making another change in the distribution of their time. Over time, "good" choices increase an agent's returns and move him into the fit group.³

³ Details for this decision and a schematic of simulation programming appear in Appendix 1.

This evolutionary procedure leads to a simple and natural decision process.

Agents evaluate their lot by comparing themselves to others and the least successful agents (those whose past choices have rendered them least fit) have the greatest incentive to change. Changes are made randomly as well. Rather than exploring their payoff functions and calculating the marginal effects of alternative decisions, individuals simply try something a bit different (or they may decide not to make a change after all). While being over simplified, this process reflects decision-making commonly observed in everyday life. Many individuals gauge "success" relative to others and make decisions based on incomplete information.

Over many rounds of decision-making and re-evaluation agents tend to converge on a strategy and society takes on a relatively stable set of macroeconomic characteristics, what I call a steady state. Naturally there is turmoil at the microeconomic level as there is always a least-fit portion of the population, but eventually these micro adjustments consist of agents switching among slightly different choices that have little impact on themselves or the overall performance of society.

This computational model is the vehicle that carries the investigation for the balance of the paper. A series experiments will be conducted in which groups of agents make production and protection decisions in different environments. The aggregate characteristics of these societies are then compared once they have reached their steady state. The experiments can be sorted into two categories. The first set assigns all agents to a single community so individual decisions affect all agents in the population. The second set of experiments internalizes the decision to form communities and agents can move from one group to another. Thus the number and size of communities is endogenous, becoming an emergent property of the simulations. Following a comparison

of these different models, section III explores some dynamics as agents choose among a variety of organizational options and section IV offers some tentative conclusions.

II. A. A Single Community:

Initially suppose all peasants belong to the same community which means social protection is shared by all. We compare three different "treatments" in this single community context. The first treatment alters the size of the population; the second changes the level of technology affecting the efficiency of social protection (α); and the third introduces a public authority that determines social protection. After running a series of experiments under each scenario, we compare their steady-state, aggregate characteristics. Of particular interest is:

- a. the average, per agent, expenditure on self protection
- b. the average, per agent, expenditure on social protection
- c. the number of bandits
- d. the average satisfaction of peasants (following equation 1), and
- e. the amount of rent-seeking or non-productive resource use.

Rent-seeking refers to the use of resources for non-productive endeavors and includes all expenditures on self and social protection as well as the production lost when agents turn to banditry. In later experiments with an endogenous population we will also be interested in the emergent number of communities, their size, and their comparable welfare measures.

The first and most primitive set of experiments apes the analytical structure above. Agents decide whether to become peasants or bandits. If they choose peasantry, they then decide to engage in some level of private protection and/or social protection. Imposing the constraint of a single population implies that all peasants are part of the community; thus if there are any contributions to social protection, all peasants in the system share its benefits. However, because peasants are not compelled to contributethere is no mechanism to forcibly collect social protection payments—they have opportunities to free ride.

Population is the first treatment factor, that is, a series of experiments will be run with populations of 10, 20, 100, 500, and 1000 individuals. These experiments computationally explore the analytical model's result of how population, k, affects satisfaction. Each treatment level is simulated twenty times: twenty simulations have a population of 10 people; another twenty simulations have 20 people, and so forth. Note that the number of periods for which the simulation is run differs across treatment levels; a population of only ten individuals reaches its steady state quickly while a population of 1000 people may take thousands of rounds to reach its steady state.

Table 1.1 brings together the results of the one hundred simulations to facilitate the comparison of behavior in different populations. The specific numbers in the table (and subsequent tables) report the average characteristics of each treatment once it reaches it steady state.

[Table 1.1 about here]

As seen in Table 1.1, the quality of life deteriorates with population growth. In societies with larger populations bandits become more prevalent, individuals spend more of their time on self protection, communal efforts at protection virtually disappear, satisfaction falls, and resources spent on rent-seeking activities rise. These differences reflect shirking. With small populations, the marginal benefit of communal protection for the individual outweighs the cost to that individual, and free-riding is stemmed. Consequently, smaller communities can take advantage of the more productive technology of social protection which leads to less crime and higher income. Small is beautiful.

As the population grows, individuals can incrementally improve their own situation by eliminating their contributions to social protection and free riding on the contributions of others. But since the opportunity for these personal gains applies to all peasants, everyone shirks and the total amount of social protection practically disappears. Since society is no longer taking advantage of the superior technology embodied in communal protection, social welfare falls as well. Just as the classic tragedy of the commons addresses the overuse of a public good, here citizens neglect a public good that requires maintenance.

The second treatment explores the impact of protection technology by fixing the population at 20 individuals and running a series of experiments changing α , the social protection technology parameter. Showing the averaged the steady state results in Table 1.2 we see that improved protection technology raises social welfare. As social protection becomes more efficient there are fewer bandits, less time is devoted to self-protection, average satisfaction rises, and aggregate rent-seeking expenditures decline.⁴

[insert Table 1.2 about here]

The results of these first two sets of experiments follow with the analytical model's predictions presented in proposition 1 and agree with the anthropological literature (see Olsen, 1965). Smaller populations achieve greater cooperation and satisfaction. Similarly the impact of protection technology in the artificial populations also tracks the predictions of the analytical model. The congruence of these two approaches "docks" the computational model in the sense of Axtell, Axelrod, Epstein,

⁴ Notice the jump in agent satisfaction when $\alpha = 0.1$. In this case there are no bandits, and even though some output remains unprotected the peasants keep it.

and Cohen (1997) and suggests it is a reasonable starting point for further exploration. The first extension is to introduce a simple governmental authority, a dictator.

The Dictator

Now let us repeat these simulations but allow one of the peasants (randomly selected at some random time) to acquire the ability to extract tribute from other peasants. He can then apply that tribute to social protection but is not required to do so. Call this agent a dictator. Peasants and bandits go about their business as before with the least fit portion of the population becoming candidates for change. Peasants' choices are now limited to changing their self-protection expenditures or switching occupations because the dictator determines contributions to social protection (tribute) as well as expenditures on social protection.

The dictator's objective is to increase his own satisfaction, s^d , which is a function of his tribute, his expenditures on social protection, and the number of peasants in his domain. So,

(3)
$$s^d = \sum_{i=1}^k (t_i - g_i)$$

where t_i is the tribute demanded from peasant *i* and g_i is the dictator's per-person spending on social protection.

In the following simulations the dictator's decisions are designed as a step-by-step process that is consistent with the decision making of the peasants. He does not explicitly maximize the wealth function in (3). Instead, as soon as a dictator emerges in the simulation, the initial level of tribute demanded from each peasant is set equal to the average amount of social contributions currently going to social protection. Initial spending on social protection is automatically set at 90% of this value (guaranteeing the dictator a 10% profit). Thereafter the dictator randomly determines whether he wants to change his tribute by a predetermined small increment, or to change his spending on social protection. If the adjustment increases his total wealth he makes that change and considers another in the next round. Incremental adjustment continues as long as the dictator's total wealth, s^d , rises. If the dictator's wealth remains constant or declines then he halts his adjustment of tribute and expenditures.

Table 2 presents steady-state results from a series of simulations in which dictators emerge. In addition to the social measures presented in Table 1.1, Table 2 also shows the average tribute paid by each peasant, the dictator's per capita expenditures on social protection as well as the dictator's satisfaction.

[insert Table 2 about here]

Because the dictator is not required to apply his tribute to protection, and because he has a captive population (agents cannot leave the society), he can extort peasants and does so. His presence depresses every measure of social welfare as revealed in a comparison of Table 1.1 and Table 2. The number of bandits essentially doubles, average satisfaction falls by 15% to 40%, and the proportion of the societies' potential output devoted to nonproductive activities (rent-seeking) rises by 25%. The decline in peasant welfare is aggravated by the dictator's capture of much of society's output. In general, peasants earn about one-third of what they earn in the previous simulations.

As far as most individuals are concerned, population matters little when a dictator dominates society. He collects the lion's share of output and subjects are left with an unsavory choice, to produce and receive little in return, or to become bandits robbing peasants who have little to steal. The one winner in this society is the dictator. He amasses tremendous wealth, earning several hundred times the income of the average

peasant. Finally, while population has little impact on the welfare of peasants, it has a large impact on the dictator's satisfaction. His well-being is directly related to the number of his subjects because there are more individuals to pay tribute; conversely, small populations give rise to petty dictators. An implication is that, given an opportunity, dictators may want to expand their domain.

B. Multiple Communities and Mobility

In the remaining experiments the decision to belong to a particular community is endogenous. Simply put, peasants now have another choice, their location. Peasants are free to join groups and leave groups at will. Such mobility allows agents to "vote with their feet" by leaving a community when the local level of social protection is not to their liking. This option was first suggested by Tiebout (1956) and became the basis for the theory of clubs.⁵ As we shall see, spatial choice opens a rich set of possibilities and has significant impacts on the final decisions of our agents.

In these experiments the decision to become a member of a particular group is approached in the same fashion as the decision to self-protect. All agents are ranked according to their performance (equations 1 and 2) and the least fit consider changing their behavior. In addition to changing the amount of effort invested in self- and social protection, agents can also move. If a peasant joins group A, his social protection contributions accrue solely to the members of A; joining group B directs his contributions to members of B, and so on. We call these groups villages. Peasants can still become bandits, and vice versa, but bandits belong to no particular village and prey on peasants from all communities.

⁵ See Sandler and Tschirhart (1980) for a review of club theory.

With the decision to form communities being internalized, we need to stipulate a minimum size of a village. Consider the absence of such a size requirement. If an individual can take advantage of the superior social protection technology and reap all the benefits, there is no free riding problem and everyone would become an independent agent contributing only to "social" protection. We get lots of villages with a population of one. But this social protection would be odd, provided by a single individual and solely consumed by that same individual—which is our definition of self-protection. To avoid this trivial solution the social protection technology, α , is redefined as

(4)
$$\alpha = \begin{cases} \frac{2}{1+k^{\nu}} & \text{if } k^{\nu} < m \\ 0.25 & \text{if } k^{\nu} \ge m \end{cases}$$

where k^{ν} is the number of peasants who are citizens of village ν . Thus, the return to social protection increases with population. Because it takes at least two people to specialize, cooperate, or spell one another, social protection is not superior until at least two people cooperate. Additional peasants further increase the social protection technology, but this does not continue indefinitely. At some population level, *m*, the gains to size stabilize.⁶ Intuitively, while two individuals have some opportunities for mutual gain, there are additional gains with three, four, or more individuals.

During this simulation, village selection simply becomes another option available to peasants. But when a peasant decides to move, he needs some method of choosing where to go. We utilize two different village selection routines. Initially, village selection is random. When a peasant elects to move, he simply draws the name of a

⁶ Other technology functions in which $\alpha = f(k)$ were also explored and produced similar results. In this manuscript, m = 8.

village out of a hat and moves there.⁷ In the second village selection routine, the peasant looks around in his neighborhood, compares the average income earned by peasants in those neighboring villages and moves to the richest of those villages. His neighborhood is defined spatially. Visualize the agents spread out on a two-dimensional grid. An agent's neighborhood is defined as the eight neighbors that surround his position. In Figure 1, the eight neighbors of agent *i* are numbered 1-8.

[insert Figure 1 about here]

Because peasants are now free to join or leave villages at will, population (village size) is determined by the actors, not the researcher. With village size being endogenous it is no longer necessary to run simulations with different sizes of populations as long as there are enough agents to initially start several villages. Therefore the remaining simulations occur in a world with 1000 agents. Again, each treatment will be simulated twenty times with different initial populations, that is, each simulation begins with a different initial conditions, some agents spend more on social protection others on private protection still others start as bandits.

The impact of each treatment is measured by comparing the aggregate social measures used to evaluate single communities: expenditures on self-protection, expenditures on social protection, average satisfaction, the prevalence of banditry, and rent-seeking costs. In addition however, we are also interested in the number of communities established as well as their average size. Table 3 presents the results of the agent decisions with each of the two village selection routines.

[insert Table 3 about here]

⁷ The selected village could be vacant in which case the peasant is alone and there are no gains to social protection. Later, another could join this independent peasant or he may decide to move once again.

First consider column (a), the society in which peasants move randomly. Given the opportunity to construct villages, peasants seem eager to do so and few choose to remain alone (about 3%). Small villages also appear to be the preference as the average population is about 12 peasants.⁸ This preference for smallness is consistent with the literature and reflects our earlier finding that small villages have higher social welfare. In small villages the individual returns to social protection are large enough to overcome the free-riding incentive. Consequently villages can take advantage of the more efficient social-protection technology, leading to fewer bandits, less rent-seeking behavior, and greater satisfaction.

As it turns out these results depend critically on the search routine adopted by peasants. Compare the results in column (b) in which the same agents face the same set of decisions, but peasants who wish to move choose their preferred village by searching through the neighborhood and moving to the village that has the highest average income. Even though these peasants have more information and greater cognitive ability than the agents in the previous model, overall social welfare declines and individual satisfaction falls. Villages are much larger and contain more bandits, more resources are consumed by rent-seeking activities, and communal protection drops dramatically.

This outcome seems counterintuitive. Agents who are given the opportunity to make choices after evaluating a set of alternatives actually end up worse off than agents who blindly choose a village at random. Information and choice degrade agent welfare.⁹ But there is a rationale for this counterintuitive result: congestion. When peasants

⁸ In primitive societies one might think of this as twelve families.

⁹ Exploratory simulations that allow peasants to compare the average incomes of all villages in the society suggest a similar result. Those agents do slightly better than the peasants who can only search a neighborhood, but they perform much worse than agents who choose randomly.

evaluate a set of alternative villages and choose their best option, they converge on a particular community. As this village gets larger, free-riding behavior becomes beneficial and agents begin to opt out of social contributions. Thus, the advantages of social protection are lost and the quality of life falls.

Random village selection (column a) actually dissipates the population and reduces congestion. Villages that are doing well grow only by chance. And as a particular village gets large enough that free riding begins to depress aggregate income, some subset of the citizens choose to move and are randomly dispersed across the society. The congestion that arises when peasants specifically choose their new village has a substantial impact on the peasants' quality of life. Comparing columns (a) and (b) of Table 3, we see that the number of bandits doubles, average satisfaction falls by a third, and rent-seeking expenditures rise by 35%.

When compared to the previous single-community results, Table 3 has a Tiebout (1956), "voting with their feet" feel to it. Peasants move from villages with a less desirable mix of social and self protection to those with a more desirable mix. These villages could be considered to be clubs that can cater to their members wishes more efficiently than a larger community that lumps all of the players together. But there are crucial differences. Club theory typically addresses individuals with heterogeneous preferences and gains are made by grouping like individuals. In this study all agents share the same utility function, and, there is no exclusion mechanism to keep others out of a club. It seems as if the random movement acts as this exclusion mechanism. When peasants decide to move (or join a new club) their location is determined randomly. One can't say I want to join your club. On the other hand, given the ability to join a specific group (as in column b) congestion rises and satisfaction falls.

Many villages and multiple dictators

The next permutation combines attributes from the previous experiments. Villages are once again an endogenous choice variable, and so communities emerge and grow only when peasants choose to live together. We bring back the dictators by randomly choosing peasants who, under a certain set of circumstances, acquire the authority to extract tribute and set social protection expenditures. With multiple villages being a viable outcome, multiple dictators can arise, although we restrict their existence to one per village. Nevertheless, the presence of multiple villages gives peasants an option they did not possess in Table 2: they can flee from a dictator's village. Thus, the ruler has to compete with the environment provided by other dictators in society as well as with the peasants' ability to produce and protect their own output and form villages without dictators.

The circumstances under which a dictator arises are the following. At random intervals an agent is randomly selected. If that agent is a peasant (not a bandit), if that peasant belongs to a village of sufficient size (a population larger than an arbitrarily set critical size, k^d), and if no dictator occupies that village, then that agent becomes a dictator. This means he acquires the ability to set tribute and to choose how much of that revenue will be spent on community protection *for his village*. As events unfold, if the population of a village falls below a smaller critical value, $k^{d'}$, the dictator's venture fails. That means he once again becomes a peasant and the citizens of that village resume setting their own levels of private and social protection.¹⁰ In later rounds another dictator may emerge in this village, or the same individual may try again.

¹⁰ Several levels of k^d were used in experiments, but in the reported simulations, $k^d = 8$ and $k^{d'} = 5$.

Peasants have the same options available as above, plus the ability to relocate.

They set their own level of private protection, they set their own level of contributions to social protection if they are in a village without a dictator, and they can become bandits. If a peasant belongs to a village with a dictator or moves to a village with a dictator, his contributions to social protection (tribute) and the amount of those contributions spent on social protection (expenditure) is determined by that village's dictator. The decision to move is once again determined in two ways: random village selection and moving to the village with the highest average income in the neighborhood. Table 4 presents the results of both types of village selection in this environment.

[insert Table 4 about here]

The particular village selection routine has a much smaller impact on average peasant income than in the previous example. Peasants who move to the best village tend to make a bit more, but the difference is small. Similarly, more bandits emerge, and peasants spend a bit more on self protection in the villages that evolve after a neighborhood search.¹¹ But in the previous model (Table 3) peasants who searched the neighborhood before moving received less satisfaction, endured much more crime, and spent almost twice as much on their own self-protection than their randomly moving counterparts.

At the same time, congestion is clearly evident. As peasants choose to move to the best neighborhood, the resulting village becomes quite large. In every simulation, the entire population of peasants eventually resided in the same village which was then ruled by a single dictator. But this congestion does not lead to a significant loss of welfare as it

¹¹Because the simulations within each column behaved so similarly, even these small differences are statistically relevant.

did in Table 3. In fact, dictators are beneficial. Their presence leads to greater social welfare, communities with fewer bandits, and higher average satisfaction for peasants and bandits.

Compare the results in the first column of Table 3 (randomly formed villages with no dictators) to the results in the first column of Table 4 (randomly formed villages with dictators). The differences in welfare are small. If agents can relocate, dictators have little impact on the aggregate performance of these societies. Each society has about the same number of bandits, approximately the same number of villages, and rent seeking consumes a similar amount of the economies' potential output. There is a microeconomic impact, however, as some wealth is transferred from the peasants to the dictators.

The reason for this similarity is straightforward. Peasants move away from dictators who extort their citizens, and since those peasants' relocations are random they are scattered about creating small villages. Small villages support only petty dictators (or no dictator—about half of the villages have no ruler) and more of the villages' wealth tends to go to the peasants.

Also note what happens to the dictator's income when peasants can relocate. Dictators ruling over immobile subjects (Table 2) earn many times the income their counterparts earn in societies in which peasants are free to change villages (Table 4). This implies dictators have an incentive to restrict their subjects' emigration; a lesson well understood by real-life dictators. Through the ages autocrats have restricted travel, persecuted defectors, built walls around their domain, and patrolled those walls to keep their population at home. Peasant mobility makes dictators worse off, but it increases the social welfare of the village's inhabitants as a further comparison of Tables 2 and 4

reveals. Average satisfaction is more than five times as high in the latter case, and crime is much lower with about 25% of the population choosing crime as opposed to 75%.

Why do two, single-dictator regimes produce such different results? Without the opportunity to move from community to community, the agents in Table 2 are captive to the dictator's whims and he extorts his subjects. In Table 4 agents can migrate and dictators who extort their citizens drive peasants away. Peasants then join villages without a dictator or a village whose dictator has a more equitable mix between tribute and protection expenditures. Eventually only the most benevolent dictator survives. Notice in column (b) of Table 4 how the average tribute collected is quite close to the dictator's spending on social protection. Again, for their own self-interest, dictators have an incentive to contain their population, but their only option for containment is benevolence.

Perhaps even more curious is that over time these dictatorships (with mobile peasants) outperform villages without dictators. In this latest experiment, every simulation evolved into a single entity run by a dictator, and this large dictatorial society outperformed a similar-sized, free society. A means test between the incomes of peasants reported in column (b) of Table 4 and Table 3 shows this difference to be statistically relevant. Dictators interrupt free riding. Absent a dictator these villages tend to grow until shirking becomes rampant, individuals stop contributing to social protection and the village no longer receives the advantage of its superior technology. In the villages shown in Table 4, dictators collect a premium for their services but they eliminate free-riding behavior and can take advantage of the superior social-protection technology. At the same time, the competition created by peasants having the option of fleeing a particular village reduces the surplus the dictator is capable of extracting from society. Thus, the

benefit derived from squelching free riders outweighs the cost of paying a dictator. Greater protection is provided with fewer resources, and welfare rises.

Democracy

The final simulations explore a democratic society. As pointed out by Olsen (1996) the emergence of democracy as a form of government is poorly understood. Why would a leader choose democracy when dictatorship is financially more rewarding? The conventional answer (Olsen, 1996 and Dahl, 1971) is that sometimes a balance of power or political stalemate prohibits autocracy and a sharing of power (some form of democracy) becomes a viable option. Thus, democracy is largely an historical accident. The present model does not formally incorporate that level of detail, but once again it reflects those ideas. Herein, at random times, a random agent is selected. If this particular agent is a peasant (not a bandit) who exists in a village with at least k^{D} peasants $(k^{D} = 10$ in the following simulations) and if that village has no dictator, then that peasant's village becomes a democracy. Unlike the randomly selected dictator, this agent does not have the power to make himself an autocrat, but he can ignite democracy. So, in this experiment it is historical conditions, the path of decisions that have already occurred in the simulation, that lead to certain communities fulfilling the necessary preconditions for democracy (a sufficiently large population and the absence of a dictator). Stated more stylishly, if a Thomas Jefferson (the randomly chosen agent) arises in a village that has the correct attributes, he establishes a democracy in that village.

Once established, this democracy is a simple, town-hall type of affair in which the contributions to social protection (taxes) and the expenditures for social protection are determined by election. The process unfolds thusly. Each period, a ballot is put forth that raises, reduces, or leaves unchanged social spending and/or taxes. The particular

combination of policies is determined randomly as long as total spending is less than or equal to taxes (no budget deficits). For example, in one period the proposition put before the village's population might be to raise taxes and leave spending unchanged. Then, each individual agent analyzes the impact of that social change on his personal satisfaction (equation 1). Peasants vote in favor of the proposal if it increases their satisfaction and vote against if satisfaction falls. Indifferent peasants toss a coin. Votes are summed and if the yeas outweigh the nays, the new tax and spending proposals are adopted and applied to everyone in the population. In the next period another random proposal is brought before the population.

In these villages, individuals still make personal choices. The amount of time spent on personal protection (and thus the balance of time devoted to production), the career decision (to become a bandit or not), and the decision to relocate are still individually determined. Only contributions to social protection and spending on social protection are determined by a vote. Peasants who lose an election are worse off because they must pay the taxes and share the protection chosen by the majority.¹² However, if subsequent elections continue to whittle away their utility, they can move to another village. Finally, if enough peasants leave a village (so that $k^{\nu} < k^{D}$ -3), this democracy fails and the village reverts to a communal group that relies on voluntary cooperation.

It was also assumed that running a democracy is costly. Elections use resources and laws need to be enforced (taxes collected). To keep the system simple, it was assumed that administrative costs rise with village size, i.e.,

¹² Even though all peasants have the same payoff function, they do not have the same opinion on social protection because their decision history differs. Thus if one agent spends more on self protection than another, the benefits of additional social protection differs.

$$c = \frac{k^v}{5000} \,.$$

Thus, governments display diminishing returns and these costs are included as a deadweight loss to the individual agents. And again, peasants who decide to move make their selection in two different ways, either randomly choosing a village or after exploring the villages in the neighborhood and moving to the one with the highest average income.

The results of the democratic simulations appear in Table 5 and the first result to notice is that all of these democratically organized villages produce a higher standard of living for the agents than any of the other systems studied in this paper. Second, a means test finds no significant difference in the average level of satisfaction between these two democratic societies (columns a and b in Table 5). Under democracy, the village location routine does not affect average satisfaction.

[insert Table 5 about here]

There is, however, a difference in the overall organization of society. If agents move randomly there are many more villages which tend to be much smaller. There are also fewer bandits. Larger democracies have higher taxes and spend a bit more on social protection, while the smaller communities tend to spend more on self-protection. Each of these mean differences emerges as statistically significant at a 0.01 level of confidence. So these villages accomplish their equally pleasant lifestyle in two different ways: small towns rely a bit more on self-protection and have lower taxes while larger communities provide more social services (collective protection) and collect higher taxes.

As in previous experiments, the eventual size of these villages depends on the particular relocation rule adopted. But congestion caused problems in the previous

simulations as larger villages suffered from extensive free-riding and the benefits of social protection were lost. Consequently larger villages had significantly lower levels of satisfaction. In the democratic simulations congestion still arises but it does not generate the negative externalities seen previously. The government coerces contributions to social protection at the level selected by the majority and free-riding is avoided.

III. Some Dynamics:

Agent-based modeling also allows us to track the decisions of the agents over time. We can watch each type of village arise, to persist, to flourish, or perish. As a last exhibit, I present a simulation in which the agents' choices include all of the options considered in this paper. Initially 10% of the agents were designated as bandits (randomly determined) and the rest were peasants, belonging to no village. They then were allowed to make decisions on their contributions to social protection, private protection, their occupation, and whether to band together communally, or to create or join a democracy or dictatorship. Before an individual could form a dictatorship or democracy, he had to satisfy the same constraints imposed in the previous models. He had to be randomly selected, of the proper type, residing in a village of sufficient size, which is not already a democracy or dictatorship. The simulation was run until a relatively stable distribution of agent types emerged. We then trace the changes in organizational structure over time. That time path is shown in Figure 2.

[insert Figure 2 about here]

Almost immediately peasants start to form voluntary groups, labeled communes, to protect themselves from the rising number of bandits.¹³ Apparently crime pays relatively well in these early stages, as the number of bandits also rises. Eventually the

¹³ In Figure 2, the peasants in a commune are not included unless there are at least five people in the group.

communal villages become sufficiently large and dictatorships begin to emerge. Given the initially exploitive tendencies of these dictators, there is turmoil as peasants enter and leave those villages, dictators' rise and fall, and the total number of peasants residing in dictatorships fluctuates. Meanwhile, communities continue to grow and democracies eventually begin to form. While democracy is the last organizational construct to emerge, the proportion of the population residing in democracies increases steadily as new democratic villages arise and existing democracies grow in size. Eventually democracies dominate and the other types of communities disappear. This final arrangement persists. There continues to be some adjustment at the micro-level as there is always at least one agent who earns less than everyone else. That agent and any other agent within one standard deviation of his satisfaction still alter their behavior, but those individuals have minimal effect on aggregate welfare. Meanwhile these democracies continue to propose and vote on new tax and spending levels, but, being satisfied, the citizens tend to defeat those initiatives and perpetuate the status quo.

IV. Concluding Remarks

We know people turn to one another for protection. We also know that any communally consumed commodity, like protection, is subject to over-use and underproduction. So how difficult is it for a group of independent agents to overcome the tragedy of the commons and reap the advantages afforded by cooperation? This paper suggests that it can be simple. If agents compare themselves to others and experiment with their behavior a bit when they find their situation is dire (in a relative sense), they stumble onto the benefits of cooperation. If those benefits are satisfactory enough (again relative to others) they have little incentive to experiment further. Consequently cooperation becomes an emergent characteristic of their society.

Certainly other methods of reaching decisions may also lead to cooperation, such as a system of enforceable contracts (Olsen, 1965), a benevolent central planner (Sandler, 1992), or learning about credible threats and strategic responses (Axelrod, 1996). But this paper demonstrates how easy it can be. Agents with limited cognitive ability and little information often cooperate, albeit in small groups.

There is a local public goods flavor ala Tiebout (1956) in the simulations with multiple villages. However, Tiebout and most club theory incorporate heterogeneous utility functions and clubs, or communities, which offer differing levels of the public good under consideration. We have neither. Utility functions are homogeneous and at the end of the day each village in a simulation is offering almost identical levels of protection. But even with those differences the taste of Tiebout lingers. Mobility leads to higher levels of aggregate welfare by disciplining dictators and (under certain circumstances) stemming the shirking that arises in large communities. At the least, this study shows how agent-based modeling could be an effective method to explore the theory of clubs, and some studies have taken such steps (see Kollman, Miller and Page, 1977).

This study also identifies two attributes that may explain how civilizations were able to grow and yet avoid shirking. Technology, and in particular technology that increases the advantages of social protection relaxes those bounds and increases the "natural" size of communities. It should be noted that many of the advances in protection are also useful for aggression, creating an additional reason for cooperation. While that increative is not studied here, history is replete with examples of warfare technology preceding the expansion of a civilization.

The second attribute that appears to promote larger communities is leadership. Even if there are technological advantages associated with socially produced protection, communities are likely to be limited in size as the private incentives to shirk soon outweigh the advantages of cooperation. However, if an individual, or by extension some organization, can ensure individual contributions to the collective good then the superior technology of communal protection can be captured by larger groups. Under those conditions, communities can grow quite large and have increased social welfare and greater personal wealth.

Our simulations also confirm the threat of dictatorship to the welfare of a community. But, we suggest an important caveat to that general conclusion: if the citizens of a dictatorship can flee, the autocrat's power is severely constrained. A mobile population turns dictators into "protection entrepreneurs" who have to compete with one another for a citizenry. Clearly this lesson has been learned by autocratic rulers who, throughout history, have systematically prohibited migration and suppressed and/or misrepresented information about the welfare of others outside their society.

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Appendix I

This appendix provides detail into how agents make their production, protection, and location decisions. First, the key components of the program are explained then a schematic provides an overview of the program's organization.

1. Create agents

Agent creation gives agents five things:

- (i) a name (a unique number) that does not change throughout experiment
- (ii) an initial level of self protection
- (iii) and initial level of contribution to social protection
- (iv) an occupation
- (v) a village.

Each agent is assigned a unique number that remains unchanged throughout the experiment. This number is the reference used to store an agent's characteristics. Initial levels of self protection are randomly assigned a level between 0 and 0.25 (differing by 0.01 increments) and initial levels of social protection are randomly assigned quantities between 0 and 0.15 (again 0.01 increments). Each agent is also assigned an occupation (being either a peasant or a bandit). In these experiments approximately 10% (randomly determined) agents started as bandits. Several test runs were executed with other initial characteristics, for example, no protection expenditures of any kind, no bandits, only bandits, but these changes had little effect on the eventual steady-state characteristics of the society. In the models allowing mobility between villages agents are initially assigned a village number that is unique to each agent. Thus to start there are as many villages as there are people and each village has only one occupant.

That the initial parameters have no effect on the steady-state characteristics makes intuitive sense. Consider a society starting with no bandits and no protection. All agents earn 1 unit of output. They are all tied for the least fit agent and thus all have a chance of changing their activity. Some do. Some spend resources on protection others become bandits. In round two, all agents spending zero on protection see their income drop to zero (there are now bandits who take unprotected output). These agents become candidates for change in the next round and soon we are on a path to the steady state.

- 2. Calculate satisfaction of agents.
 - (i) calculate the per peasant average spending on social protection in each village, \bar{y}_{ν} (in the first round this is simply equal to the agent's own contributions).
 - (ii) calculate the peasant's satisfaction, s_i , using formula (1).
 - (iii) calculate the amount of unprotected output in the economy,

$$\sum (1-x_i-\overline{y}_i^{\alpha})(1-x_i-y_i).$$

- (iv) use that to calculate bandit satisfaction (divide by the number of bandits).
- (iv) calculate the dictator's satisfaction (if applicable) send result to 3.
- 3. Calculate cutoff (lower bound) of satisfaction defining agents considering a change.

Find the minimum level of satisfaction in the society (the least happy agent be he a peasant or bandit) call that s_{min} . Using all agents calculate the standard deviation of satisfaction and call it σ_s . Construct a bound or cutoff equal to $(s_{min} + \sigma_s)$.

4. Make changes:

- (i) randomly select an agent
- (ii) compare his satisfaction, s_i , to the bound. If $s_i >= (s_{min} + \sigma_s)$ select another agent randomly. If $s_i < (s_{min} + \sigma_s)$ go to change routine.

4a. Change routine

- (a) Draw a number out of hat (between 1 and 7).
 - if =1, make no change.
 - if =2 change occupation (bandit becomes peasant, peasant->bandit)
 - if =3 increase self protection by 0.01
 - if =4 decrease self protection by 0.01
 - if =5 increase social protection contributions by 0.01
 - if =6 decrease social protection contributions by 0.01
 - if =7 move (if applicable) go to moving routine
- (b) Check for anomalies, such as, protection<0 or protection>1, and disallow such choices.

(iii) continue until k_c agents have been given the opportunity to make changes. The value of k_c ranges from a low of two agents (for populations with only ten agents) to a high of 50 agents.

It should be noted that even if $k_v = 50$, there may not be fifty agents making a change, because some agents choose option one (no change) and others may be selected more than once in the same round. Those agents make two or more changes in one period.

5. Moving

There are two moving routines and only one is in force during a simulation. In the following schematic the dashed lines indicated that only one routine is used for a given simulation.

(i)In the first routine an agent simply draws a number out of a hat and the agent becomes a member of that village.

(ii) In the second routine an agent looks around his neighborhood (Figure 1) to see what villages are in his neighborhood. He then compares the average income of the agents in each of those villages and moves to the one with the highest average satisfaction. Note, if an agent is completely surrounded by a single village he stays where he is in this routine.





Population	10	20	100	500	1000
	34.6%	35.3%	38.3%	44.0%	43.5%
% Danuits	(.051)	(.048)	(.033)	(.016)	(.024)
calf protection	.3001	.3368	.4198	.4497	.4516
self-protection	(.005)	(.009)	(.001)	(.0002)	(.0008)
communal protect	.1001	.0179	.00076	.00011	.00011
	(.001)	(.001)	(.0002)	(.00007)	(.0000)
average satisfaction	.4493	.4239	.3534	.3075	.3096
	(.026)	(.025)	(.019)	(.010)	(.014)
rent-seeking	.5491	.5750	.6432	.6919	.6914
	(.033)	(.028)	(.019)	(.009)	(.013)

Table 1.1 Population and the Returns to Protection

* The top number in each cell is the average steady-state outcome of twenty simulations. The standard deviation lies below in parentheses.

Table 1.2
Social Protection Technology and Social Welfare

protection technology	$\alpha = 0.75$	$\alpha = 0.5$	$\alpha = 0.25$	<i>α</i> =0.1
% Pondita	55.3%	49.6%	35.3%	0
% Dalluits	(.035)	(.054)	(.048)	(0)
solf protoction	.4187	.4069	.3368	.1793
sen-protection	(.019)	(.021)	(.009)	(.010)
communal protect	.00037	.0037	.0179	.003
	(.001)	(.003)	(.001)	(.0003)
average satisfaction	.2568	.2914	.4239	.8097
	(.019)	(.027)	(.025)	(.004)
rent-seeking	.7416	.7043	.5750	.1823
	(.021)	(.029)	(.028)	(.010)

*The top number is the average steady-state outcome of twenty simulations. The standard deviation lies below in parentheses. **population = 20

Population	10	20	100	500	1000
% Bandits	66%	86%	80.6%	77.9%	78.1%
	(.168)	(.127)	(.072)	(.231)	(.343)
colf protoction	.1864	.139	.0143	.0047	.0008
sen-protection	(.031)	(.025)	(.016)	(.005)	(.0012)
	.7349	.8495	.8104	.7913	.7862
rent-seeking	(.106)	(.059)	(.073)	(.044)	(.034)
average tribute	.3622	.6415	.7601	.6953	.7254
	(.085)	(.035)	(.097)	(.071)	(.059)
social expenditures	.0126	.0056	.0087	.0192	.0229
	(.007)	(.004)	(.0037)	(.004)	(.004)
average	.1463	.0601	.0833	.1112	.1102
satisfaction**	(.069)	(.022)	(.035)	(.027)	(.023)
dictator income	1.25	1.82	13.97	73.15	151.8
	(.523)	(.746)	(3.83)	(8.422)	(13.69)

Table 2 The Dictator

(.740) (.740) (.740) (.740) (.7422) (.13.09)
*The top number is the average steady-state outcome of twenty simulations. The standard deviation lies below in parentheses.
** excludes dictator's satisfaction

	Random	Peasants Select
	Village Selection	Best Village
	(a)	(b)
0/ Pondita	18.8 %	41.2%
% Daliults	(.804)	(3.64)
calf must action	.2498	.4431
sen-protection	(.003)	(.007)
communal protection	.1245	.0007
communal protection	(.002)	(.0005)
avanage esticfaction	.5072	.3267
average satisfaction	(.003)	(.023)
nont coolein o	.4922	.6730
rent-seeking	(.004)	(.023)
# ***11.0 000	60.7	2.1
# villages	(2.65)	(.755)
	12.73	338.7
average village size	(.584)	(133.5)

Table 3 Endogenous Village Selection

*The top number is the average steady-state outcome of twenty simulations. The standard deviation lies below in parentheses.

	Random	Peasants Select	
	Village Selection	Best Village	
	(a)	(b)	
0/ Dondita	21.8%	26.5%	
% Daliuits	(1.05)	(1.65)	
colf protoction	.1993	.2159	
sen-protection	(.004)	(.005)	
rant cooling	.4826	.4760	
Tent-seeking	(.004)	(.013)	
	61.7	1	
# villages	(2.18)	(0)	
average village	12.0	735.2	
size	(.480)	(16.49)	
average	.4909	.5178	
satisfaction**	(.018)	(.010)	
avorago tributo	.1453	.0677	
average tribute	(.004)	(.004)	
average	.0658	.0621	
expenditures	(.007)	(.003)	
number of	34.4	1	
dictators	(3.75)	(0)	
average dictators'	23.75	6.59	
income	(2.51)	(2.41)	

Table 4 Dictators: Endogenous Village Selection

*The top number is the average steady-state outcome of twenty simulations. The standard deviation lies below in parentheses. **excludes the dictator's satisfaction

	Random	Peasants Select	
	Village Selection	Best Village	
	(a)	(b)	
% Randita	24.4%	27.6%	
% Dalluits	(.623)	(.714)	
solf protection	.2020	.1440	
sen-protection	(.004)	(.079)	
rant cooking	.4894	.4830	
Tent-seeking	(.005)	(.011)	
# villages	54.5	12.3	
# villages	(3.11)	(1.61)	
average village	13.9	60.3	
size	(.838)	(8.28)	
average	.5292	.5291	
satisfaction	(.0007)	(.079)	
avaraga tavas	.1226	.1421	
average taxes	(.001)	(.001)	
average	.1225	.1419	
expenditures	(.001)	(.002)	

Table 5Democracy: Endogenous Village Selection

*The top number is the average steady-state outcome of twenty simulations. The standard deviation lies below in parentheses.

Figure 1 The Moore Neighborhood for agent *i*

•	•	•	•	•
•	1	2	3	•
•	8	i	4	•
•	7	6	5	•
•	•	•	•	•





