March 2002

Predation, Efficiency, and Inequality

by

HERSCHEL I. GROSSMAN AND MINSEONG KIM*

This paper analyzes a general-equilibrium model in which each person can choose to be either a producer or a predator. This model shows how predation breaks the link between the interpersonal distribution of productive resources and the interpersonal distribution of consumption. Specifically, we find that in this model the Rawlsian criterion of maximizing the expected consumption of the least advantaged person selects an unegalitarian distribution of productive resources in which a positive fraction of people have only the minimum possible endowment of productive resources. Also, an egalitarian distribution of productive resources is not even Pareto efficient. (JEL: D31, D50, D60, D74)

Standard general-equilibrium analysis takes secure property rights as given and analyzes how the choices of agents and their interactions in markets determine the allocation of resources among productive activities and the distribution of the resulting product. But, this formulation of the economic problem is incomplete because it ignores both the fact that

*We thank anonymous referees for helpful comments.

agents, who can be either individuals or groups, create, challenge, and defend the property rights that inform allocation and distribution and the related fact that these activities require the allocation of potentially productive resources, including time and effort, to appropriative competition and conflict.

In recent years recognition of these facts has motivated a research program that extends general-equilibrium analysis to endogenize the creation and security of claims to property. In the quest for tractability this research program has spawned alternative analytical frameworks. Which alternative is more useful depends on the objective of the modeling.

One analytical framework models each agent as dividing its endowment of potentially productive resources among productive activities and appropriative activities. This framework can allow both for appropriative competition over productive resources and for appropriative conflict over final products.[1]

The other analytical framework models each agent as choosing to be either a producer or a predator, a predator being an agent who produces nothing, but lives by appropriating from producers. This framework recognizes that some people, or even some groups, like the Vikings and the Mongols, eschew productive activities to specialize in predatory activities. In this framework producers also can allocate resources to guarding their production against predators. This framework accommodates the modeling of appropriative conflict over final products.[2,3]

[1]Examples include a seminal contribution by HAAVELMO [1954, pages 91-98] as well as BUSH AND MAYER [1974], SKAPERDAS [1992], HIRSHLEIFER [1995], and GROSSMAN AND KIM [1995]. For a succinct introduction to this analytical framework, see GROSSMAN [2001].

[2]Examples include a seminal contribution by USHER [1987] as well as GROSSMAN [1998], [2002] and GROSSMAN AND KIM [2001]. Although these papers model activities as either predatory, or productive, or a way to guard against predators, some activities, such as litigating, are not easily classified in this way.

[3]GROSSMAN AND KIM [2000], [2002] extend this framework to allow for the existence of moral people, who are self-constrained not to choose to be predators.

The present paper investigates the distributional effects of predation in a model in which individuals choose to specialize in either production or predation. We begin by analyzing how both each person's choice to be a producer or a predator and each producer's decision to allocate resources to guarding against predators depend on the technology of predation and on the interpersonal distribution of productive resources. Then, we engage in a thought experiment that shows simply and clearly how predation breaks the link between the interpersonal distribution of productive resources and the interpersonal distribution of consumption. To dramatize this disconnection, we focus our thought experiment on deriving the interpersonal distribution of productive resources that satisfies the criterion, suggested by RAWLS [1971], of maximizing the expected consumption of the person with the lowest expected consumption. We show that this distribution is radically different in a model that allows for predation than in a model that abstracts from predation.[4] We also show how predation changes the specification of Pareto efficient interpersonal distributions of productive resources.

1. *Overview of the Analysis*

In our model people can be either well endowed or poorly endowed with productive resources. These resources are inalienable, like natural ability or other elements of human capital, and, hence, are not themselves subject to appropriative competition. We assume that each person's choice to be either a producer or a predator depends on whether production or predation would yield higher expected consumption for him (or her). Furthermore, we assume that poorly endowed people have a comparative advantage as predators. To implement this assumption in the simplest way, we specify technologies of production and predation such that productive resources enhance a person's ability to produce, but do not enhance a person's effectiveness as a predator.

In our model the interpersonal distribution of productive resources has two dimensions.

[4] GROSSMAN AND KIM [2001] includes a complementary analysis that derives the interpersonal distribution of productive resources that maximizes the consumption of well endowed people.

One dimension is the fractions of people who are well endowed and poorly endowed. The other dimension is the relative endowments of well endowed people and poorly endowed people. If the number of poorly endowed people goes to zero, or, equivalently, if the endowments of well endowed people and poorly endowed people converge, then we define the distribution of productive resources to be egalitarian.

Our analysis of the choice to be a producer or a predator reveals two critical properties of the equilibrium. First, the equilibrium ratio of predators to producers has a positive minimum value that is determined by the technology of predation. This property implies that, even though the poorly endowed people have a comparative advantage as predators, if the ratio of poorly endowed people to well endowed people were small, then not only all of the poorly endowed people but also some of the well endowed people would choose to be predators. Second, the equilibrium ratio of predators to producers exceeds its minimum value if and only if the ratio of poorly endowed people to well endowed people is larger than this minimum value. This property implies that a smaller ratio of poorly endowed people to well endowed people would imply a smaller ratio of predators to producers if and only if the ratio of poorly endowed people to well endowed people were larger than the minimum ratio of predators to producers.

Next, we turn to the derivation of the interpersonal distribution of productive resources that satisfies the Rawlsian criterion of maximizing the expected consumption of the person with the lowest expected consumption. (In our model, expected consumption is a cardinal index of expected utility.) Given the assumptions of our model, if we were to ignore the possibility of predation, then aggregate consumption would depend only on the aggregate endowment of productive resources, and the interpersonal distribution of consumption would correspond to the interpersonal distribution of productive resources. Accordingly, if we were to ignore the possibility of predation, then the Rawlsian criterion would select the egalitarian distribution of productive resources.

The possibility that people choose to be predators changes this conclusion for two reasons: First, predation decreases aggregate consumption, both because the productive resources of predators are wasted by not being used productively and because producers sacrifice production by allocating productive resources to guarding against predators. Second, predation increases the expected consumption of poorly endowed people relative to the expected consumption of well endowed people. This effect is similar to what HIRSHLEIFER [1991] has called the paradox of power.

After allowing for these two effects of predation we find that the Rawlsian criterion selects an unegalitarian distribution of productive resources in which the ratio of poorly endowed people to well endowed people equals the minimum ratio of predators to producers, and in which the poorly endowed people have the minimum possible endowment of productive resources. In the resulting Rawlsian equilibrium, only poorly endowed people would choose to be predators, and the ratio of predators to producers would be minimized. Also, the sum of the productive resources that people waste by choosing to be predators and the productive resources that producers allocate to guarding against predators would be minimized. Accordingly, aggregate consumption would be maximized. In addition, in the Rawlsian equilibrium predation would equalize the expected consumption of the well endowed people and the poorly endowed people. We also show that, allowing for predation, the egalitarian distribution is not even Pareto efficient.

2. Analytical Framework

To describe the interpersonal distribution of productive resources, let k denote the productive resources of each poorly endowed person, where $k \geq 0$, let K denote the productive resources of each well endowed person, where $K \geq k$, and let U denote the ratio of poorly endowed people to well endowed people. The fraction of people who are poorly endowed is $U/(1+U)$, and the fraction of people who are well endowed is $1/(1+U)$. Aside from their endowments of productive resources, people are otherwise identical.

Let Ω denote the average endowment of productive resources, where

$$\Omega = \frac{1}{1+U}\ K + \frac{U}{1+U}\ k. \tag{1}$$

In analyzing the welfare properties of the interpersonal distribution of productive resources, we hold Ω fixed. For a given value of Ω, we can relate any one of the parameters, k, K, and U, to the other two. For example, equation (1) implies that K equals $\Omega + U(\Omega - k)$. Thus, for a given value of Ω, the combination of U and k implies a value for K and, hence, fully describes the interpersonal distribution of productive resources. Recall that, if U goes to zero, or, equivalently, if K and k go to Ω, then we define the distribution of productive resources to be egalitarian.

Let N denote the fraction of people who are well endowed and who choose to be producers, where $N \leq 1/(1+U)$, let n denote the fraction of people who are poorly endowed and who choose to be producers, where $n \leq U/(1+U)$, and let R denote the ratio of predators to producers. The fraction of people, whether well endowed or poorly endowed, who choose to be predators is $R/(1+R)$. Thus, we have $N + n + R/(1+R) = 1$.

Each producer can choose to allocate some of his productive resources to guarding his production from predators. Guarding by a producer includes all actions that are costly but have the effect of decreasing the ability of predators to appropriate his production. Examples of ways of guarding against predators include the locating of production in inconvenient but secure places, the production of things that are harder for predators to appropriate, the installation of locks, the building of walls, and the hiring of guards. For simplicity, we focus on the total amount of resources that a producer allocates to guarding, abstracting from different ways of guarding.

Let G denote the ratio of the resources that a producer allocates to guarding to the resources that he allocates to production. The fraction of his resources that a producer allocates to guarding is $G/(1+G)$.

To simplify the analysis of the choice between being a producer and a predator, we assume that a unit of productive resources can produce one unit of consumables. We also assume that individual productive activities are independent, and we abstract from trade in either productive inputs or consumables. The number of units of consumables that a producer actually produces equals the product of his endowment of productive resources and the fraction of his resources that he allocates to production. Thus, a well endowed producer produces $K/(1+G)$ units of consumables, and a poorly endowed producer would produce $k/(1+G)$ units of consumables.

Let p denote the fraction of the consumables that he produces that a producer expects to retain. He expects predators to appropriate the fraction $1-p$. To determine p, assume that the larger is the ratio of predators to producers the more predators each producer encounters. Also, assume that the larger is the ratio of the resources that a producer allocates to guarding against predators to the production that he has to guard the less success a predator has in each encounter. These assumptions imply that p depends negatively on R and positively on G.

To incorporate this story into the analysis in a simple and tractable way, assume that

$$p = \begin{cases} \dfrac{1}{1+\theta R/G} & \text{for} \quad R > 0, \quad \theta > 0 \\ 1 & \text{for} \quad R = 0. \end{cases} \tag{2}$$

In equation (2), the parameter θ, which embodies the technology of predation, determines the effectiveness of predators in appropriating consumables for given values of R and G. The specification that p depends on the number of predators but not on the identity of the predators reflects the assumption that well endowed people and poorly endowed people are equally effective at predation. Equation (2) also abstracts from externalities in guarding.

Although equation (2) is easy to rationalize, it is a generic black box that conceals the process of predation, just as the standard generic production function conceals the process of production. For example, the relation between appropriative inputs and the appropriative outcome described by equation (2) could involve either the use of force or a peaceful settlement under the threat of force.[5]

Let C denote the expected consumption of a well endowed producer, and let c denote the expected consumption of a poorly endowed producer. After allowing for the fraction of productive resources allocated to guarding against predators and for the fraction of consumables that producers expect predators to appropriate, we have

$$C = \frac{p\ K}{1+G} \tag{3}$$

and

$$c = \frac{p\ k}{1+G}. \tag{4}$$

Let D denote the expected consumption of a predator. Abstracting from destruction of consumables as the result of predation, and assuming that each predator expects to be equally successful, D equals $1-p$ times per capita production of consumables divided by the fraction of people who choose to be predators. Using the result derived in the next paragraph that well endowed producers and poorly endowed producers choose the same guarding ratio, per capita production of consumables is $(NK+nk)/(1+G)$. Thus, we have

$$D = \frac{1-p}{R/(1+R)}\ \frac{NK+nk}{1+G}. \tag{5}$$

3. The Ratio of Predators to Producers

Consider first the decision of a producer to allocate his productive resources between production and guarding against predators. Taking R as given, each well endowed producer chooses G to maximize C, and any poorly endowed producer chooses G to maximize c. To analyze these choice problems we substitute equation (2) into equations (3) and (4), and

[5] Many authors, ranging from SCHELLING [1966] in his game-theoretic modeling of conflict to ANDERTON [2001] in a recent survey of the economics of conflict, have stressed that the possibility of applying force in appropriative interactions influences production and distribution even if force is not actually applied.

we find that the value of G that satisfies both the condition $dC/dG = 0$ and the condition $dc/dG = 0$ is

$$G = \sqrt{\theta R}. \tag{6}$$

This results says that well endowed producers and poorly endowed producers would choose the same guarding ratio.

Consider next the decisions of well endowed people and poorly endowed people to be producers or predators. To decide whether to be a producer or a predator, each well endowed person compares the values of C and D, as given by equations (3) and (5), and each poorly endowed person compares the values of c and D, as given by equations (4) and (5). In taking as given his potential expected consumption as a producer or as a predator, each person in effect takes as given the choices by other people to be producers or predators, as reflected in R, and the choice by producers to allocate a fraction of their resources to guarding against predators, as reflected in G. He knows that if he chooses to be a producer, then he will allocate the same fraction of his resources to guarding as do other producers.

There are three possible cases to consider:[6]

1. If D is equal to C but is larger than c, then well endowed people have the same expected consumption whether they choose to be producers or predators, whereas poorly endowed people have higher expected consumption if they choose to be predators. Hence, R is either equal to or larger than U. Also, n equals zero, and, hence, N equals $1/(1+R)$. Consequently, using equations (3), (5), and (6) we find that D equal to C implies that R equals θ. Thus, we can have D equal to C but larger than c only if U is equal to or smaller than θ.

[6] We can easily show that D larger than both c and C, which would imply that every person would choose to be a predator, and D smaller than both c and C, which would imply that every person would choose to be a producer, would imply contradictions.

2. If D is smaller than C but larger than c, then poorly endowed people have higher expected consumption if they choose to be predators, whereas well endowed people have higher expected consumption if they choose to be producers. Hence, R is equal to U. Also, again n equals zero, and, hence, N equals $1/(1+R)$. Consequently, using equations (3), (5), and (6) we find that D smaller than C implies that R is larger than θ. Thus, we can have D smaller than C but larger than c only if U is larger than θ.

3. If D is smaller than C but equal to c, then poorly endowed people have the same expected consumption whether they choose to be producers or predators, whereas well endowed people have higher expected consumption if they choose to be producers. Hence, R is equal to or smaller than U. Also, N equals $1/(1+U)$, and, hence, n equals $U/(1+U) - R/(1+R)$. Consequently, using equations (4), (5), and (6) we find that equating D to c implies that again R is larger than θ. Thus, we can have D smaller than C but equal to c only if U is larger than θ.

This analysis implies that the equilibrium ratio of predators to producers satisfies the following conditions:[7]

$$\text{If } U \leq \theta, \quad \text{then } R = \theta. \tag{7.1}$$

$$\text{If } U > \theta, \quad \text{then } U \geq R > \theta. \tag{7.2}$$

According to condition (7.1), if U is either equal to or smaller than θ, then in equilibrium all of the poorly endowed people and enough of the well endowed people choose to be predators to make R equal θ. According to condition (7.2), if U is larger than θ, then in equilibrium all of the well endowed people choose to be producers, but enough of the poorly endowed people choose to be predators to make R larger than θ.

[7] See GROSSMAN [1998] for a complete solution of this model for R.

Importantly, regardless of the value of U, the ratio of predators to producers cannot be smaller than θ. To see why R smaller than θ would imply a contradiction, observe that, if R were smaller than θ, then, according to equation (6), G would be smaller than θ. But, if G would be smaller than θ, then D would be larger than C, and every person would choose to be a predator.

4. The Rawlsian Distribution of Resources

As mentioned above, to show most vividly how predation breaks the link between the interpersonal distribution of productive resources and the interpersonal distribution of expected consumption, we derive the interpersonal distribution of productive resources that satisfies the Rawlsian criterion of maximizing the expected consumption of the person with the lowest expected consumption. Recall that in our model the productive technology is linear, and individual productive activities are independent. Hence, if we were to ignore the possibility of predation, then aggregate production and consumption would be independent of the interpersonal distribution of resources, and each person's consumption would equal his production. Consequently, the egalitarian distribution of resources would imply both maximum aggregate production and the same production and consumption for every person. Thus, abstracting from predation, the egalitarian distribution of resources would satisfy the Rawlsian criterion.

Allowing for predation radically alters this conclusion. Because in equilibrium well endowed people either have higher expected consumption if they choose to be producers or have the same expected consumption whether they choose to be producers or predators, the expected consumption of every well endowed person equals C. Conditions (7.1) and (7.2), together with equations (2), (3), and (6), imply that in equilibrium C satisfies the following conditions:

(8.1) $$\text{If } U \leq \theta, \quad \text{then } C = \frac{K}{(1+\theta)^2}.$$

(8.2) If $U > \theta$, then $C = \dfrac{K}{(1+\sqrt{\theta R})^2}$, where $U \geq R > \theta$.

Recall that from equation (1) K equals $\Omega + U(\Omega - k)$.

Furthermore, because in equilibrium poorly endowed people either have higher expected consumption if they choose to be predators or have the same expected consumption whether they choose to be producers or predators, the expected consumption of every poorly endowed person equals D. Conditions (7.1) and (7.2), together with equations (1), (2), (5), and (6), imply that in equilibrium D satisfies the following conditions:

(9.1) If $U \leq \theta$, then $D = \dfrac{K}{(1+\theta)^2}$.

(9.2) If $U > \theta$, then $D = [\Omega + R(\Omega - k)] \dfrac{\sqrt{\theta / R}}{(1+\sqrt{\theta R})^2}$, where $U \geq R > \theta$.

The mathematical appendix shows the calculations involved in deriving conditions (9.1) and (9.2).

Comparing conditions (8.1) and (9.1) we see that, if U is smaller than or equal to θ, then D is equal to C. Comparing conditions (8.2) and (9.2), after replacing K in condition (8.2) with $\Omega + U(\Omega - k)$, and using the fact that, if U is larger than θ, then R is larger than θ but not larger than U, we see that, if U is larger than θ, then D is smaller than C. Thus, D is either equal to or smaller than C. Accordingly, to apply the Rawlsian criterion we only have to determine what distribution of productive resources would imply the maximum value of D.

Replacing K in condition (9.1) with $\Omega + U(\Omega - k)$, we see that, if U equals θ and k equals zero, then D equals $\Omega/(1+\theta)$. We also see immediately that, for a given value of Ω, $\Omega/(1+\theta)$ is larger than the value of D implied by condition (9.1) for all combinations of U and k such that either U is smaller than θ or k is positive. Next, using the property that, if U is larger than θ, then R is larger than θ, some simple algebra, spelled out in the mathematical appendix, reveals that, for a given value of Ω, $\Omega/(1+\theta)$

is larger than the value of D implied by condition (9.2) for all combinations of U and k such that U is larger than θ.

These results imply that the maximum value of D is uniquely associated with the combination U equal to θ and k equal to zero. In other words, the expected consumption of the person who has the lowest expected consumption would be maximized with an unegalitarian distribution of productive resources such that the ratio of poorly endowed people to well endowed people equals the minimum equilibrium ratio of predators to producers and such that each poorly endowed person has the minimum possible endowment of productive resources. With this unegalitarian distribution of productive resources the poorly endowed people would choose to be predators, the well endowed people would choose to be producers, and each poorly endowed person would expect to appropriate from the well endowed people an amount that is larger than what his expected consumption would be with any other interpersonal distribution of productive resources, including the egalitarian distribution.

In addition, with U equal to θ and k equal to zero, C would equal $\Omega/(1+\theta)$. Thus, the unegalitarian Rawlsian distribution of productive resources would result in equal expected consumption for the poorly endowed and the well endowed. For comparison, conditions (8.1) and (9.1) imply that with the egalitarian distribution of productive resources both C and D would equal $\Omega/(1+\theta)^2$, and, hence, that both C and D would be smaller that with the Rawlsian distribution by the factor $1/(1+\theta)$.

The result that the Rawlsian criterion selects the distribution of productive resources that has U equal to θ and k equal to zero is easy to explain. As we have seen, in equilibrium the ratio of predators to producers, R, is not smaller than θ. Also, if U is larger than θ, then R is larger than θ. Thus, with U equal to θ, R would be minimized.

Furthermore, with both U and R equal to θ, all of the predators would be poorly endowed people, and each predator would waste the endowment of productive resources of a poorly endowed person. Thus, minimizing k would minimize the amount of productive resources that each predator wastes.

We also have to consider the total amount of productive resources that producers allocate to guarding against predators. With all of the producers being well endowed people, this amount would equal $[1/(1+R)][G/(1+G)]K$, which is an increasing function of K and, hence, for a given value of Ω is inversely related to k. But, with both U and R equal to θ, the sum of $[R/(1+R)]k$, the total amount of resources that people waste by choosing to be predators, and $[1/(1+R)][G/(1+G)]K$ is an increasing function of k. In other words, with all of the predators being poorly endowed people and all of the producers being well endowed people, decreasing the endowment of poorly endowed people would decrease the amount of resources that people waste by choosing to be predators by more than it would increase the amount of resources that producers allocate to guarding against predators. Accordingly, the combination of U equal to θ and k equal to zero would minimize the negative effect of predation on the aggregate production of consumables.

Finally, because with U equal to θ the expected consumption of a well endowed producer would be equal to the expected consumption of a predator, the expected consumption of well endowed people and poorly endowed people would be equal. Thus, with U equal to θ, setting k equal to zero, by maximizing aggregate consumption, would maximize expected consumption for every person and, hence, for the person with the lowest expected consumption.

5. Pareto Efficient Distributions of Resources

A Pareto efficient distribution of productive resources is a distribution such that no redistribution of resources would result in a Pareto improvement. A Pareto improvement is an increase in the expected utility of at least one person without a decrease in the expected utility of any other person. Again, in the present model, expected consumption is a cardinal index of expected utility.

In this model, if we were to ignore the possibility of predation, then all interpersonal distributions of productive resources would be Pareto efficient. Without the possibility of predation, any redistribution of resources would reduce somebody's expected consumption. Allowing for the possibility of predation, however, introduces the possibility that a redistribution of resources could result in a Pareto improvement.

Because the Rawlsian distribution of productive resources would imply maximum expected consumption for the person with the lowest expected consumption, the Rawlsian distribution is Pareto efficient. What about the egalitarian distribution of resources? As we have seen, with the egalitarian distribution D would be equal to $\Omega/(1+\theta)^2$, whereas with the Rawlsian distribution D would be equal to $\Omega/(1+\theta)$. In addition, with either the egalitarian distribution or the Rawlsian distribution C and D would be equal. Thus, with the Rawlsian distribution of resources C as well as D would be higher than with the egalitarian distribution. In other words, the Rawlsian distribution would result in a Pareto improvement over the egalitarian distribution. Thus, not only does the egalitarian distribution not satisfy the Rawlsian criterion of maximizing the expected consumption of the person with the lowest expected consumption, the egalitarian distribution of resources is not even Pareto efficient.

Further analysis of the solutions for C and D enables us to determine exactly which distributions of productive resources are Pareto efficient. These solutions imply that, for given values of k and Ω, starting with any value of U smaller than θ, an increase in U to θ would increase both C and D. In addition, the solutions for C and D imply that, for given values of U and Ω, and starting with any positive value of k, a decrease in k to zero also would increase both C and D. These properties imply that no distribution of resources in which either U is smaller than θ or k is positive is Pareto efficient. This result obtains because either an increase in U towards θ or a decrease in k towards zero would redistribute resources from predators to producers.

In addition to the Rawlsian distribution of productive resources, does the set of Pareto efficient distributions include any other distributions in which U is equal to or larger than θ and k equals zero? To answer this question, observe that the solutions for C and D imply that with U larger than θ the expected consumption of a poorly endowed person, D, would be smaller than the expected consumption of a well endowed person, C. Thus, starting with U larger than θ, any increase in U, by changing the status of some people from well endowed to poorly endowed, would decrease the expected consumption of these people. Furthermore, with k equal to zero any decrease in U would require that the aggregate endowment be divided among more well endowed people. In fact, with U larger than θ and k equal to zero, a decrease in U would imply a large enough decrease in K to decrease the expected consumption of each well endowed person. These properties imply that the set of Pareto efficient distributions includes, in addition to the Rawlsian distribution, all distributions in which U is larger than θ and k equals zero.

6. Disclaimers

We remind the reader that we have engaged only in a thought experiment. We have not offered either a normative or positive analysis of economic policy. Specifically, we have not proposed the Rawlsian criterion as a policy objective, nor have we suggested that actual policy accords with the Rawlsian criterion. We have used the Rawlsian criterion only to bring out the importance of allowing for predation in analyzing how the interpersonal distribution of consumption is determined.

We also should stress that our stark results about the effect of the interpersonal distribution of productive resources on the interpersonal distribution of expected consumption have involved several simplifying assumptions. Some of these assumptions are especially noteworthy.

For example, our model assumes that productive resources do not enhance a person's effectiveness at predation. If we were to relax this assumption, while still assuming that poorly endowed people have a comparative advantage as predators, then the Rawlsian criterion might select an interpersonal distribution of productive resources that would be more egalitarian in having a positive value of k.

In addition, in each of the following examples an extended model would imply a minimum equilibrium ratio of predators to producers that is smaller that θ.

- Our model assumes that decisions to allocate resources to guarding against predators are made individually. An extended model could allow producers to make and to enforce a collective choice to allocate additional resources to guarding. Such a collective choice would enhance the effect of guarding in deterring people from choosing to be predators.[8]

- Our model does not explicitly consider the apprehension and punishment of predators. An extended model would allow for the possibility of apprehension and punishment. This possibility also would serve to deter people from choosing to be predators.

- Our model abstracts from destruction of consumables as the result of predation. An extended model could allow for destructive. With destruction the expected consumption of predators would be smaller than the amount that producers expect to lose to predation. Consequently, the choice to be a predator would be less attractive.

- Our model assumes that the fraction of the consumables that he produces that a producer expects to retain depends only on his own guarding ratio. An extended model would allow for externalities in guarding. For example, it is possible that, if you build a high wall around your property, but your neighbors do not build high walls around their properties, then your property becomes a less attractive target for burglars. This effect would cause each producer in equilibrium to choose a larger guarding ratio for

[8] GROSSMAN [1998], [2002] and GROSSMAN AND KIM [2001] explore at length the implications of the strategic advantage associated with a collective choice to allocate resources to guarding.

any given ratio of predators to producers, again enhancing the effect of guarding in deterring people from choosing to be predators.

In each of these examples of extended models, because the minimum equilibrium ratio of predators to producers would be smaller, the Rawlsian criterion would select an interpersonal distribution of productive resources that would be more egalitarian in having U smaller than θ.

7. Summary

We have analyzed a general-equilibrium model in which people can be either well endowed or poorly endowed with productive resources and in which each person can choose to be either a producer or a predator. We began by determining how the equilibrium ratio of predators to producers depends on the technology of predation and on the interpersonal distribution of resources. Because a well endowed person can produce more than a poorly endowed person, predation is less attractive for the well endowed than for the poorly endowed. But, we found that the technology of predation determines a positive minimum equilibrium ratio of predators to producers.

If the ratio of poorly endowed people to well endowed people were smaller than this minimum ratio of predators to producers, then in equilibrium all of the poorly endowed people as well as some of the well endowed people would choose to be predators. We also found that a smaller ratio of poorly endowed people to well endowed people would imply a smaller ratio of predators to producers if and only if the ratio of poorly endowed people to well endowed people were larger than the minimum ratio of predators to producers.

We then used these results to show how predation breaks the link between the interpersonal distribution of productive resources and the interpersonal distribution of consumption. Our model is such that, if we were to ignore the possibility of predation, then the Rawlsian criterion of maximizing the expected consumption of the person with the lowest expected consumption would select the egalitarian distribution of resources. But, most interestingly, we found, subject to some disclaimers, that allowing for predation the Rawlsian criterion selects an unegalitarian distribution of resources such that the ratio of poorly endowed people to well endowed people equals the minimum equilibrium ratio of predators to producers and such that poorly endowed people have only the minimum possible endowment of resources.

With this unegalitarian distribution of resources the number of people choosing to be predators would be minimized. Furthermore, all of the predators would be poorly endowed people, and the amount of resources that each poorly endowed predator wastes would be minimized. Most importantly, the unegalitarian distribution of productive resources that satisfies the Rawlsian criterion would minimize the sum of the resources that people waste by choosing to be predators and the resources that producers allocate to guarding against predators. In addition, the expected consumption of a poorly endowed predator would be equal to the expected consumption of a well endowed producer. Thus, in addition to maximizing aggregate consumption, this unegalitarian distribution of resources would maximize the expected consumption of the person with the lowest expected consumption.

Allowing for predation, we also found that the egalitarian distribution is not even Pareto efficient. The set of Pareto efficient distributions includes not only the unegalitarian distribution of resources that satisfies the Rawlsian criterion but all unegalitarian distributions such that poorly endowed people have only the minimum possible endowment of resources and such that the ratio of poorly endowed people to well endowed people is at least as large as the minimum equilibrium ratio of predators to producers. Given any distribution of resources that is not in the set of Pareto efficient distributions, either a decrease in the endowment of poorly endowed people or an increase in the ratio of poorly endowed people to well endowed people, by redistributing resources from predators to producers, would increase everyone's expected consumption.

1. Derivation of conditions (9.1) and (9.2):

From equation (5) D is the product of

$$\frac{1-p}{R/(1+R)}\ \frac{1}{1+G} \quad \text{and} \quad NK+nk.$$

Using equations (2) and (6), we have

$$\frac{1-p}{R/(1+R)}\ \frac{1}{1+G} = \frac{(1+R)\sqrt{\theta/R}}{(1+\sqrt{\theta R})^2}.$$

With U smaller than or equal to θ and R equal to θ, we have

$$\frac{(1+R)\sqrt{\theta/R}}{(1+\sqrt{\theta R})^2} = \frac{1}{1+\theta}, \quad N = \frac{1}{1+\theta}, \quad \text{and} \quad n = 0.$$

With U larger than θ and R equal to or smaller than U, we have

$$NK + nk = \frac{1}{1+U}\ K + (\frac{U}{1+U} - \frac{R}{1+R})\ k.$$

Using equation (1), we have

$$\frac{1}{1+U}\ K + (\frac{U}{1+U} - \frac{R}{1+R})\ k = \Omega - \frac{R}{1+R}\ k.$$

2. Showing that, for a given value of Ω, $\Omega/(1+\theta)$ is larger than the value of D implied by condition (9.2) for all combinations of U and k such that U is larger than θ:

For any nonnegative value of k we have

$$(1+R)\Omega\ \frac{\sqrt{\theta/R}}{(1+\sqrt{\theta R})^2}\ \geq\ [\Omega + R(\Omega - k)]\ \frac{\sqrt{\theta/R}}{(1+\sqrt{\theta R})^2}.$$

For any value of R larger than θ we have

$$\frac{\Omega}{1+\theta}\ >\ (1+R)\Omega\ \frac{\sqrt{\theta/R}}{(1+\sqrt{\theta R})^2}.$$

References

ANDERTON, C. [2001], "Conflict Economics in Christian Perspective." *Faith and Economics,* 37, 1-9.

BUSH, W. C. AND MAYER L. S. [1974], "Some Implications of Anarchy for the Distribution of Property." *Journal of Economic Theory,* 8, 401-412.

GROSSMAN, H. I. [1998], "Producers and Predators." *Pacific Economic Review,* 3, 169-187.

—— [2001], "The Creation of Effective Property Rights", *American Economic Review,* 91, 347-352.

—— [2002],"'Make Us a King': Anarchy, Predation, and the State", *European Journal of Political Economy,* 18.

—— AND KIM, M. [1995] "Swords or Plowshares? A Theory of the Security of Claims to Property." *Journal of Political Economy,* 103, 1275-1288.

—— AND —— [2000], "Predators, Moral Decay, and Moral Revivals", *European Journal of Political Economy,* 16, 173-187.

—— AND —— [2001], "Educational Policy: Egalitarian or Elitist?" unpublished, May 2001.

—— AND —— [2002], "Is a Moral Disposition Rewarded?" *Journal of Banking and Finance,*, forthcoming.

HAAVELMO, T. [1954], *A Study in the Theory of Economic Evolution,* North-Holland Publishing Company: Amsterdam.

HIRSHLEIFER, J. [1991], "The Paradox of Power," *Economics and Politics,* 3, 1991. 177-200.

—— [1995], "Anarchy and Its Breakdown," *Journal of Political Economy,* 103, 26-52.

RAWLS, J. [1971], *A Theory of Justice,* Harvard University Press: Cambridge, MA.

SCHELLING, T. [1966], *Arms and Influence,* Yale University Press: New Haven, CT.

SKAPERDAS, S. [1992], "Cooperation, Conflict, and Power in the Absence of Property

Rights," *American Economic Review,* 82, 720-739.

USHER, D. [1987], "Theft as a Paradigm for Departures from Efficiency. " *Oxford Economic Papers,* 39, 235-252; reprinted as Chapter III in USHER, D. [1992], *The Welfare Economics of Markets, Voting and Predation*, The University of Michigan Press: Ann Arbor, MI.

Herschel I. Grossman
Department of Economics
Brown University
Providence, RI 02912, USA
e-mail: Herschel_Grossman@brown.edu

Minseong Kim
School of Economics
Sungkyunkwan University
Seoul, 110-745, Republic of Korea
e-mail: minseong@empal.com