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Should We Expect Government Policy to Be Pareto Efficient?:

The Consequences of an Arrow-Debreu Economy with Violable Property Rights

by

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Introduction

Efficient use of resources is a central topic of economic discussion. In political economy literature, whether and why government policy is “efficient” is a central question (Tullock 1967, 1980, 1984, 1985, 1987, 1989; Becker 1983, 1985; Grossman and Helpman 2001). This topic also plays a key role in both the conceptual and the applied literature on agricultural political economy (Beghin 1990; Beghin and Karp 1991; Bullock 1994, 1995; Bullock and Salhofer 2003; Gardner 1993; Rausser and Zusman 1992; Zusman 1976, Zusman and Amiad 1977.) In attempt to address this question at its roots, I modify the well-known Arrow-Debreu private ownership economy. The key result of the Arrow-Debreu model is the First Fundamental Theorem of Welfare Economics, which states the conditions under which competitive equilibria will be Pareto efficient. In my modification of the Arrow-Debreu model, I allow property rights to be violable. The result is that equilibria tend not to be Pareto efficient. The new model’s implications provide insight into why “institutions” (rules, constitutions, governments, etc.) may exist: to lower the transactions costs of cooperation between interest groups, since the noncooperative social equilibrium is not Pareto efficient.

An Arrow-Debreu Private Ownership Economy

The General $I \times J \times L$ Model

Following Mas-Collel, et al. (1995, pp. 546-561), consider an abstract Arrow-Debreu

private ownership economy $\left(\left\{ X_i, \succsim_i \right\}_{i=1}^I, \left\{ Y_j \right\}_{j=1}^J, \left\{ (\omega_i, \theta_{i1}, \dots, \theta_{iJ}) \right\}_{i=1}^I \right)$. In this economy

each consumer $i = 1, \dots, I$ is characterized by a consumption set $X_i \subseteq R^L$, and a

preference relation \succsim_i . Each consumer i commands an endowment bundle $\omega_i \in R_+^L$, and has a right to a share $\theta_{ij} \in [0, 1]$ of each firm j 's profits. Each firm $j = 1, \dots, J$ is characterized by a production possibilities set (also called a "technology") $Y_j \subseteq R^L$. The *feasible set of allocations* in this economy is defined as

$$Z = \left\{ (\mathbf{x}_1, \dots, \mathbf{x}_I, \mathbf{y}_1, \dots, \mathbf{y}_J) \in \prod_{i=1}^I X_i \prod_{j=1}^J Y_j : \sum_{i=1}^I \mathbf{x}_i = \sum_{i=1}^I \omega_i + \sum_{j=1}^J \mathbf{y}_j \right\} \subset R^{L(I+J)},$$

where $\mathbf{x}_i = (x_{1i}, \dots, x_{Li})$ is i 's consumption bundle and $\mathbf{y}_j = (y_{1j}, \dots, y_{Lj})$ is firm j 's netput vector (with negative values of y_{kj} implying that firm j is using commodity k as an input in a production process. Assuming that each consumer i 's preference ordering \succsim_i is continuous and rational, then there is a continuous utility function $u_i: X_i \rightarrow R_+$ that represents \succsim_i (Mas-Colell 1995, p. 47). Any Arrow-Debreu economy has a *utilities possibilities set*, formally defined as

$$U = \{(u_1, \dots, u_I) \in R_+^I : \exists (\mathbf{x}_1, \dots, \mathbf{x}_I, \mathbf{y}_1, \dots, \mathbf{y}_J) \in A, \text{ where } u_i = u_i(\mathbf{x}_i) \text{ for } i = 1, \dots, I\}.$$

The *Pareto frontier* of the Arrow-Debreu economy is defined as

$$UP = \{(u_1, \dots, u_I) \in U : \text{there is no } (u'_1, \dots, u'_I) \in U \text{ such that } u'_i \geq u_i \text{ for all } i \text{ and } u'_i > u_i \text{ for some } i \}.$$

The question at hand is whether we should expect a society to position itself on its Pareto frontier. And by what means would a society thus position itself? Do political and/or governmental actions move an economy toward its Pareto frontier, or away from it? Of course, in the economic literature there is a long debate on the "efficiency" of government intervention. My goal in this paper is to go back to the basics of efficiency, in an attempt to throw some new light on this old debate.

An Illustration with the 2×2×2 Model

For the purposes of illustration in our upcoming discussion, consider an Arrow-Debreu economy with $I = 2$ consumers, $J = 2$ firms, and $L = 2$ goods. We will index the firms with A and B , the consumers with C and D , and the goods with 1 and 2. We assume that good 1 is used as an input into the production of good 2, but not vice-versa.

Consumption space for consumer $i \in \{A, B\}$ is $X_i \subseteq R_+^2$, and consumption space for the economy is $X_C \times X_D \subseteq R_+^4$. Each consumer is assumed endowed with some amount ω_i of good 1, any portion of which he or she may sell to firms or consume. Consumers are not endowed with good 2; rather, they must buy good 2 from firms, which produce it using good 1 as an input. Y_j is the technology of firm $j \in \{A, B\}$, and is defined using a production function: $Y_j = \{(y_{1j}, y_{2j}) : y_{2j} \leq f_j(y_{1j})\}$. The production possibilities set for the economy is

$$Y = \{(y_{1A}, y_{2A}, y_{1B}, y_{2B}) : y_{1A} + y_{1B} \leq \bar{y}_1, (y_{1A}, y_{2A}) \in Y_A, (y_{1B}, y_{2B}) \in Y_B\}.$$

The set of feasible allocations is

$$Z = \{((x_{1C}, x_{2C}), (x_{1D}, x_{2D}), (y_{1A}, y_{2A}), (y_{1B}, y_{2B})) \in R_+^8 : (y_{1A}, y_{2A}, y_{1B}, y_{2B}) \in Y, \\ x_{1C} + x_{1D} = \bar{y}_1 - y_{1A} - y_{1B}, x_{2C} + x_{2D} = f_A(y_{1A}) + f_B(y_{1B})\}.$$

The set of feasible allocations shows that after the production process is completed, the amount $\bar{y}_1 - y_{1A} - y_{1B}$ remains of good 1 for consumption, and the amount y_2 has been produced and is available for consumption. (For simplicity, we assume that all production must be consumed and cannot be thrown away.) Assuming that $y_{1A} + y_{1B} < \bar{y}_1$, netput vectors $(y_{1A}, y_{2A} = f_A(y_{1A}))$ and $(y_{1B}, y_{2B} = f_B(y_{1B}))$ imply that aggregate production of good 2 is $f_A(y_{1A}) + f_B(y_{1B})$, and that $\bar{y}_1 - y_{1A} - y_{1B}$ of good 1 has not been used as an

input, and so remains for consumers. If none of good 2 is thrown away, then a technologically feasible production plan consists of four nonnegative real numbers:

$(y_{1A}, y_{1B}, y_{2A}, y_{2B}) = (y_{1A}, y_{1B}, f_A(y_{1A}), f_B(y_{1B}))$. To shorten the notation, we may refer to such a plan simply by the pair of numbers showing input usage of each firm: (y_{1A}, y_{1B}) .

Labeling an arbitrary feasible production plan (y_{1A}^F, y_{1B}^F) , the accompanying consumption possibilities set is

$$C(y_{1A}^F, y_{1B}^F) = \left\{ (x_{1C}, x_{2C}), (x_{1D}, x_{2D}) \in R_+^4 : \begin{aligned} x_{1C} + x_{1D} &\leq \bar{y}_1 - y_{1A}^F - y_{1B}^F, \\ x_{2C} + x_{2D} &\leq f_A(y_{1A}^F) + f_B(y_{1B}^F) \end{aligned} \right\},$$

which can be represented conveniently in two dimensions by the Edgeworth box

$E(y_{1A}^F, y_{1B}^F)$ shown in figure 1. The dimensions of the box are $\bar{y}_1 - y_{1A}^F - y_{1B}^F$ by

$f_A(y_{1A}^F) + f_B(y_{1B}^F)$.

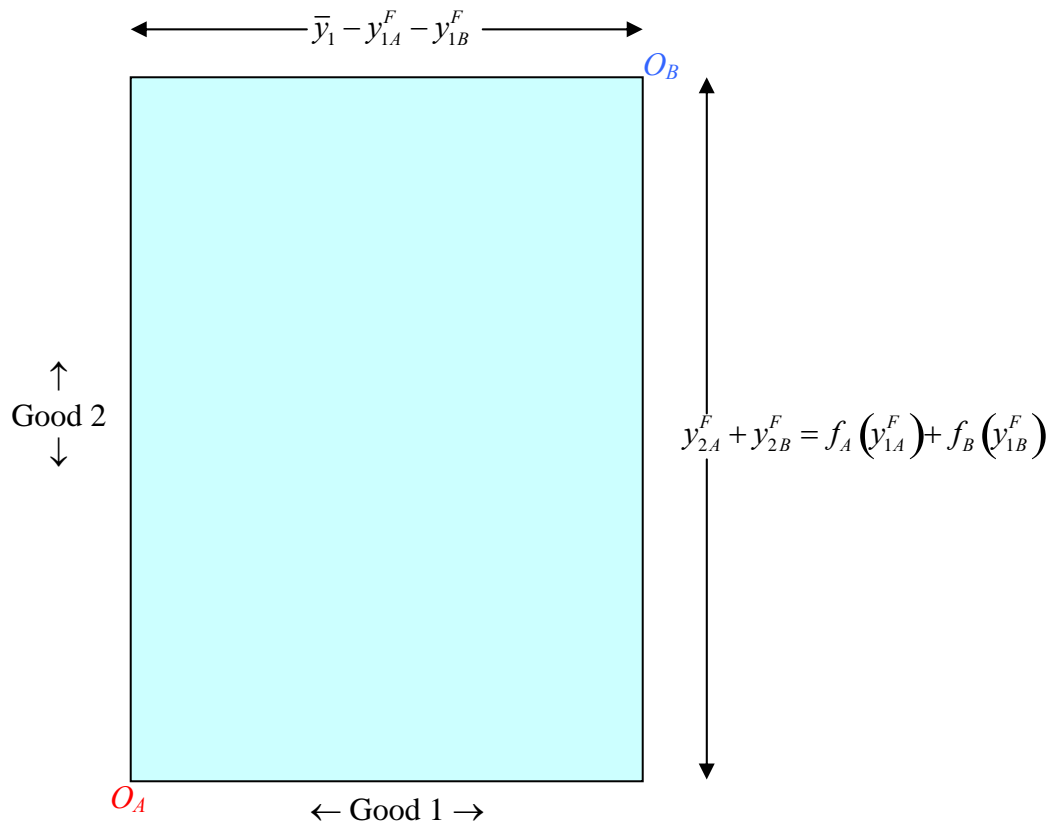


Figure 1. Arbitrary feasible production plan (y_{1A}^F, y_{1B}^F) and corresponding Edgeworth box $E(y_{1A}^F, y_{1B}^F)$.

The preferences of consumer $j \in \{C, D\}$ are represented by a utility function $u_j(x_{1j}, x_{2j}): R_+^2 \rightarrow R_+$. The vector of utility functions maps the consumption possibilities set for the production plan (y_{1A}^F, y_{1B}^F) into a utilities possibilities set for that plan:

$$U(y_{1A}^F, y_{1B}^F) = \{(u_C(x_{1C}, x_{2C}), u_D(x_{1D}, x_{2D})) : ((x_{1C}, x_{2C}), (x_{1D}, x_{2D})) \in C(y_{1A}^F, y_{1B}^F)\}$$

The utilities possibilities set for the economy is the union of the utility possibilities sets for every feasible production plan:

$$U = \{(u_C(x_{1C}, x_{2C}), u_D(x_{1D}, x_{2D})) : ((x_{1C}, x_{2C}), (x_{1D}, x_{2D}), (y_{1A}, y_{2A}), (y_{1B}, y_{2B})) \in Z\}.$$

The Pareto frontier for the economy is then defined as,

$$UP = \{(u_1, \dots, u_l) \in U : \text{there is no } (u'_1, \dots, u'_l) \in U \text{ such that } u'_i \geq u_i \text{ for all } i \text{ and } u'_i > u_i \text{ for some } i \}.$$

A utility possibilities set and its Pareto frontier are illustrated in figure 2.

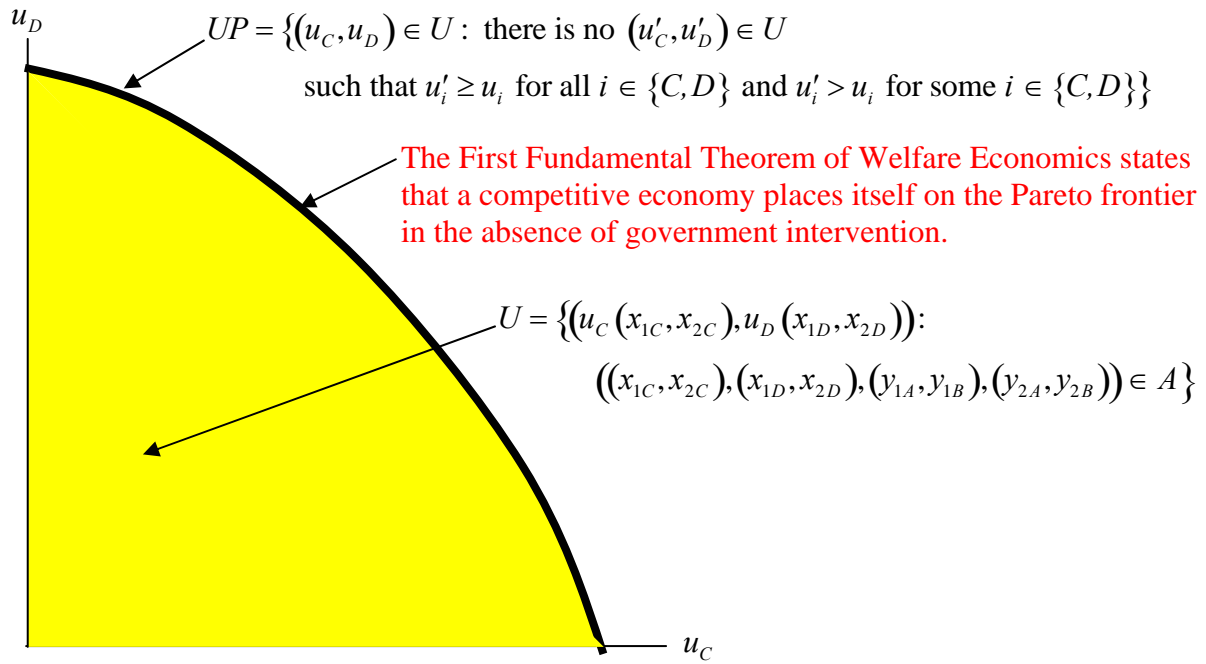


Figure 2. A Utility possibilities set and its Pareto frontier in an Arrow-Debreu economy.

Equilibrium in An Arrow-Debreu Economy with Inviolable Property Rights

An equilibrium in an Arrow-Debreu economy is a list of real numbers, consisting of a price vector and a feasible allocation $((1, p), \mathbf{z})$ such that the following properties hold:

(i) producers are profit maximizing, (ii) consumers are utility maximizing, and (iii) markets clear (Mas-Colell, pp. 547-548). Since firm i must be maximizing profits, then firm i buys an amount of input, y_{1i} at which the slope of its production function (its marginal rate of transformation, MRT), equals the slope of its iso-profit lines, $1/p$. This implies that, given the total amount of the input used by both firms, the price mechanism allocates the use of the input such that aggregate production is maximized.

Let us examine the geometric implications of an equilibrium in which some arbitrary amount $y_1^F < \bar{y}_1$ of good 1 is used in aggregate by firms A and B as the production input. In such a case, since in equilibrium each firm is maximizing profits, then for firm A and firm B marginal rates of transformation

$$MRT_A(y_{1A}^F, f_A(y_{1A}^F)) = \frac{\partial f_A(y_{1A}^F)}{\partial y_{1A}} \text{ and } MRT_B(y_{1B}^F, f_B(y_{1B}^F)) = \frac{\partial f_B(y_{1B}^F)}{\partial y_{1B}}$$

are equal to the price ratio $1/p$, and so equal to each other. Given that a total amount y_1^F of the input is used by both firms combined, the production possibilities frontier is

$$PPF(y_1^F) = \{(y_{2A}, y_{2B}) : y_{2A} = f_A(y_{1A}), y_{2B} = f_B(y_{1B}), y_{1A} + y_{1B} = y_1^F\}. \text{ (See figure 3.)}$$

Among all (y_{1A}, y_{1B}) combinations satisfying $y_{1A} + y_{1B} = y_1^F$, the combination (y_{1A}^F, y_{1B}^F) maximizes each firm's profits individually, and also maximizes aggregate production of good 2. This occurs in figure 3 at point F , where $(y_{2A}^F, y_{2B}^F) = (f_A(y_{1A}^F), f_B(y_{1B}^F))$, and where the slope of the production possibilities frontier $PPF(y_1^F)$, which is

$$-\frac{MRT_B(y_{1B}^F, f_B(y_{1B}^F))}{MRT_A(y_{1A}^F, f_A(y_{1A}^F))} = -\frac{\partial f_B(y_{1B}^F)}{\partial y_{1B}} \bigg/ \frac{\partial f_A(y_{1A}^F)}{\partial y_{1A}}, \text{ is } -1. \text{ Similarly, choosing another}$$

arbitrary amount $y_1^H < y_1^F < \bar{y}_1$, if this is to be the aggregate input use in equilibrium,

then the firm's input usages must use y_{1A}^H , and y_{1B}^H , implying production

$$(y_{2A}^H, y_{2B}^H) = (f_A(y_{1A}^H), f_B(y_{1B}^H)), \text{ meaning that if in equilibrium aggregate input usage is}$$

y_1^H , then production must be at point H in figure 1, where the slope of the production

$$\text{possibilities frontier } PPF(y_1^H), \text{ which is } -\frac{MRT_B(y_{1B}^H, f_B(y_{1B}^H))}{MRT_A(y_{1A}^H, f_A(y_{1A}^H))} = -\frac{\partial f_B(y_{1B}^H)}{\partial y_{1B}} \bigg/ \frac{\partial f_A(y_{1A}^H)}{\partial y_{1A}}, \text{ is}$$

-1 . Thus, as we let y_1 vary between 0 and \bar{y}_1 , the locus of points through $JHFK$ in

figure 3 shows all the values of (y_{2A}, y_{2B}) where the PPFs have slope of -1 . These points

are all the candidates for the equilibrium output combination (y_{2A}^*, y_{2B}^*) .

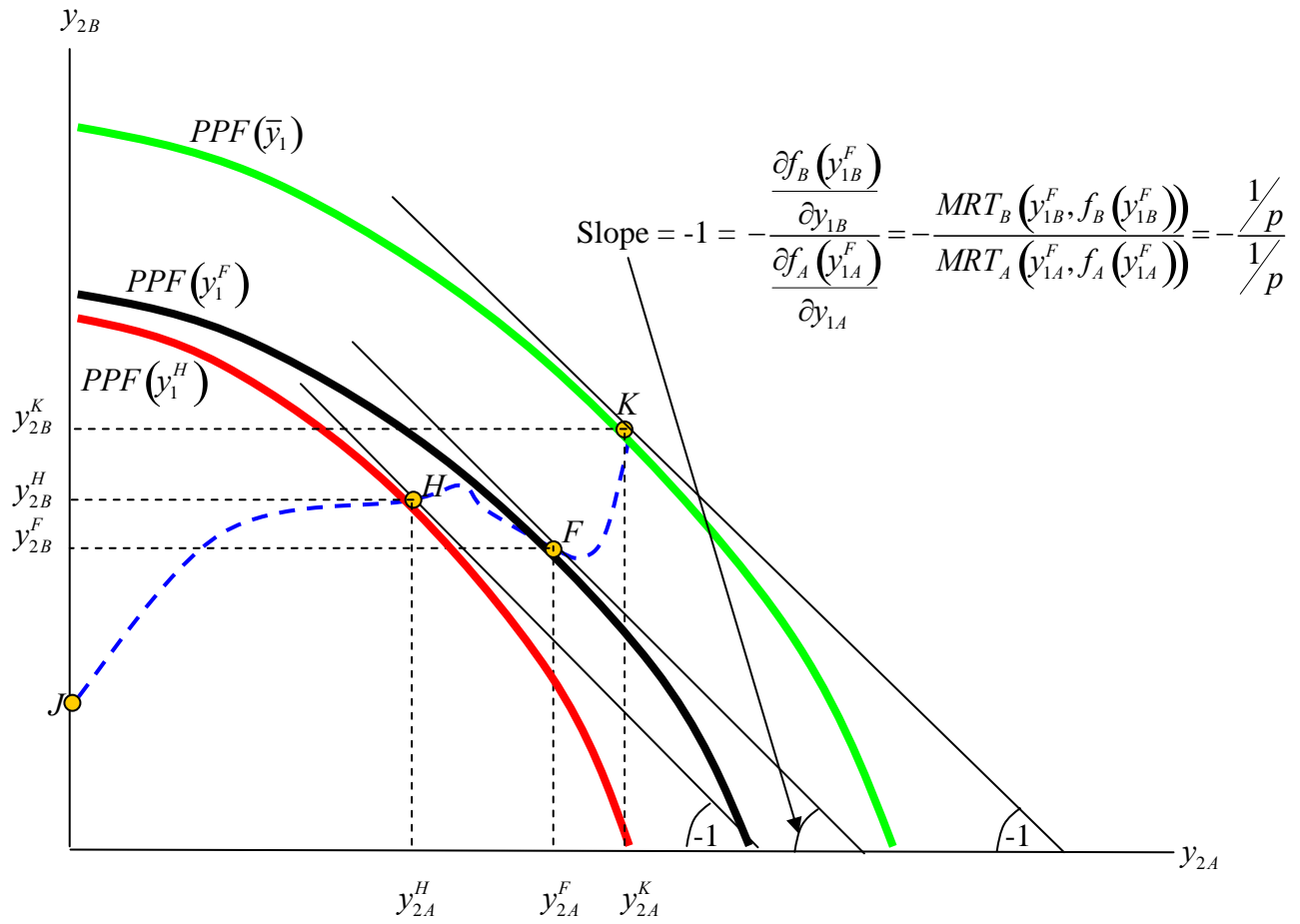


Figure 3. Possible output decisions in an Arrow-Debreu competitive equilibrium lie on locus JHFK, where the production possibilities frontiers have slope -1.

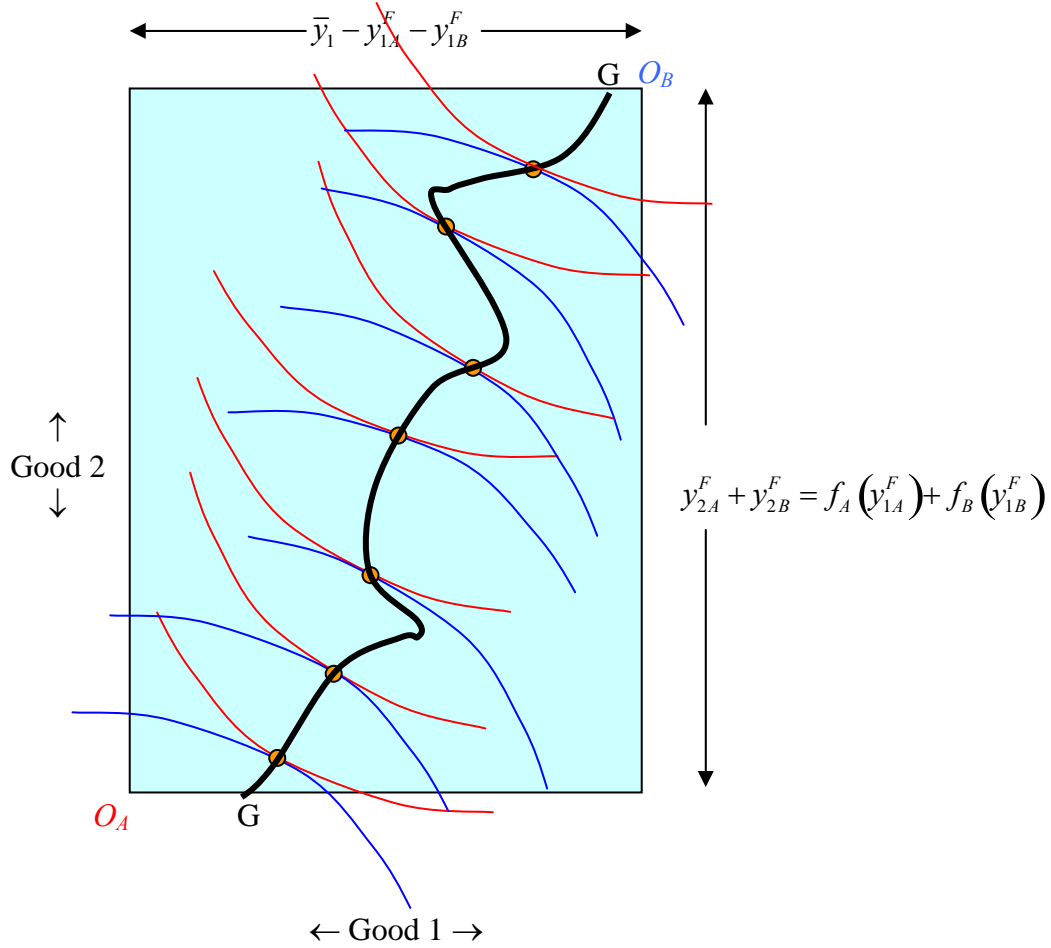


Figure 4. Edgeworth Box representing consumption possibilities set $C(y_{1A}^F, y_{1B}^F)$ in an Arrow-Debreu competitive equilibrium. The set of Pareto efficient consumption possibilities, $XPE(y_{1A}^F, y_{1B}^F)$, is represented by the “contract curve,” GG.

Properties of a Competitive Equilibrium: The First Fundamental Theorem of Welfare Economics in an Arrow-Debreu Economy with Inviolable Property Rights

The First Fundamental Theorem of Welfare Economics states that as long as preferences are non-satiated, any competitive equilibrium in an Arrow-Debreu economy results in a Pareto efficient allocation—that is, in a welfare outcome on the Pareto frontier. The geometry of the First Fundamental Theorem is well-known: at an interior competitive equilibrium in an Arrow-Debreu economy, all consumers' marginal rates of substitution between every pair of goods must be equalized, all firms' marginal rates of transformation between every pair of goods must be equalized, and every consumer's marginal rate of substitution must equal every firm's marginal rate of transformation for all pairs of goods (Mas-Colell et al. (1995, p. 564)).

We continue to consider a feasible allocation $((x_{1C}^F, x_{2C}^F), (x_{1D}^F, x_{2D}^F), (y_{1A}^F, y_{2A}^F), (y_{1B}^F, y_{2B}^F))$.

In an interior competitive equilibrium, consumer utility maximization implies that every consumer's marginal rate of substitution between good 2 and good 1 must equal the negative of the price ratio, $-p$, and so all consumers' MRSs must equal each other. That is, given the dimensions of the Edgeworth box, the competitive equilibrium amounts of consumption must lie along the contract curve GG in figure 4, the locus of points at which consumer C 's indifference curves are tangent to D 's indifference curves.

That is, given a production plan (y_{1A}, y_{1B}) , the utility possibilities set is the mapping of the consumption possibilities set (the Edgeworth box) into utility space using the vector of utility functions $(u_C(x_{1C}, x_{2C}), u_D(x_{1D}, x_{2D}))$. In the same way, given the production

plan (y_{1A}, y_{1B}) , the Pareto frontier is the mapping of the set of Pareto efficient feasible consumption plans into utility space.

A Private Ownership Economy with Violable Property Rights

In the type of Arrow-Debreu economy reviewed in the previous section, all property rights are given exogenously and are inviolable. Consumers own their endowments. Firms own their production. They give these up only voluntarily, in exchange for goods of greater value to them.

Let us generalize the idea of the Arrow-Debreu economy by assuming that property rights need not be inherently inviolable. We can imagine such an economy in which firms may use inputs not only to produce outputs, but also may resort to a different kind of technology, which enables a firm to use inputs to *steal* other firms' outputs. Along the same vein, firms may use inputs for *security*, to make it more costly for other firms to steal their output. For example, imagine a firm that can produce food by hiring labor, land, human capital (expertise in farming), and physical capital (tractors, fuel, fertilizer, etc.). Or, the firm might steal food from another firm, by hiring labor, human capital (expertise in thievery), and physical capital (bolt cutters). The latter firm may use labor and physical capital (a lock, a chain, a storage bin) to raise the costs to the former firm of stealing. For simplicity, we will assume that consumers are not able to steal. They simply own shares in firms that may steal.

In an Arrow-Debreu economy with inviolable property rights, the technology describes the production processes: how goods can be transformed into each other, producing outputs from inputs. With property rights violable, *theft* and *security* play

roles in the economy's technology. Continuing to consider the $2 \times 2 \times 2$ economy, we now denote the production technologies with a superscript P : The firms' production technologies can be described using production functions:

$$Y_A^P = \{(y_{1A}^P, y_{2A}^P) : y_{2A}^P \leq f_A(y_{1A}^P)\}$$

$$Y_B^P = \{(y_{1B}^P, y_{2B}^P) : y_{2B}^P \leq f_B(y_{1B}^P)\}.$$

Firm A 's theft technology and Firm B 's security technology can be defined using a theft/security function g_{AB} , which shows how the amount y_{2AB} that A steals from B depends on the amount y_{1A}^T of the input that A dedicates to thievery, and the amount y_{1B}^S of the input that B dedicates to security:

$$y_{2AB} = g_{AB} \left(\underbrace{y_{1A}^T}_{+}, \underbrace{y_{1B}^S}_{-} \right).$$

Similarly, firm B 's theft technology and Firm A 's security technology can be defined using the theft/security function g_{BA} , which shows how the amount y_{2BA} that B steals from A depends on the amount y_{1B}^T of the input that B dedicates to thievery, and the amount y_{1A}^S of the input that A dedicates to security:

$$y_{2BA} = g_{BA} \left(\underbrace{y_{1A}^S}_{-}, \underbrace{y_{1B}^T}_{+} \right).$$

Now we define the economy's *technology* by a *production, thievery, and security possibilities set*,

$$\tilde{Y} = \{(y_{1A}^P, y_{1A}^T, y_{1A}^S, y_{2A}^P, y_{1B}^P, y_{1B}^T, y_{1B}^S, y_{2B}^P) : y_{2A} \leq f_A(y_{1A}^P) + g_{AB}(y_{1A}^T, y_{1B}^S) - g_{BA}(y_{1A}^S, y_{1B}^T),$$

$$y_{2B} \leq f_B(y_{1B}^P) - g_{AB}(y_{1A}^T, y_{1B}^S) + g_{BA}(y_{1A}^S, y_{1B}^T),$$

$$y_{1A}^P + y_{1A}^T + y_{1A}^S + y_{1B}^P + y_{1B}^T + y_{1B}^S \leq \bar{y}_1 \}.$$

The production, thievery and security possibilities set reflects that at the end of the production, thievery, and security processes, firm j has purchased from consumers (who are also basic resource owners) and used for production, thievery, or security the following amount of the input: $y_{1j}^P + y_{1j}^T + y_{1j}^S$. Firm j has available and can sell the amount of good 2 that it produced, plus the amount it stole from firm $k \neq j$, minus the amount that firm k stole from it: $y_{2j}^P + y_{2jk}^T - y_{2kj}^S$.

The set of feasible allocations in the economy with violable property rights is

$$\tilde{Z} = \left\{ \left((x_{1C}, x_{2C}), (x_{1D}, x_{2D}), (y_{1A}^P, y_{1A}^T, y_{1A}^S, y_{2A}, y_{1B}^P, y_{1B}^T, y_{1B}^S, y_{2B}) \right) \in R_+^{12} : \right. \\ \left. \begin{aligned} & (y_{1A}^P, y_{1A}^T, y_{1A}^S, y_{2A}, y_{1B}^P, y_{1B}^T, y_{1B}^S, y_{2B}) \in \tilde{Y}, \\ & x_{1C} + x_{1D} = \bar{y}_1 - \sum_{i \in \{A, B\}} (y_{1i}^P, y_{1i}^T, y_{1i}^S) \quad x_{2C} + x_{2D} = f_A(y_{1A}) + f_B(y_{1B}) \end{aligned} \right\}.$$

The utility possibilities set and the Pareto frontier in the economy with violable property rights are the same as in the corresponding economy with inviolable property rights. In fact, the economy with inviolable property rights is simply a special case of the economy with property rights, in which $g_{AB}(y_{1A}^T, y_{1B}^S) \equiv g_{BA}(y_{1A}^S, y_{1B}^T) = 0$ for all (y_{1A}^T, y_{1B}^S) and for all (y_{1A}^S, y_{1B}^T) . That is, if the theft technologies are completely ineffective—if investing resources into theft brings no booty—then property rights are inviolable. Moreover, any production plan feasible when property rights are inviolable is also feasible when property rights are violable—provided that in the latter case no resources are spent on theft or security.

Equilibrium when Property Rights Are Violable?

As with the Arrow-Debreu economy with inviolable property rights, in the model with violable property rights we define equilibrium as a price and allocation combination under which each firm is maximizing profits subject to its technology, each consumer is maximizing utility subject to his or her budget constraint, and each market clears. The presence of the theft and security technologies changes the equilibrium of an Arrow-Debreu economy in important ways. In general, a profit-maximizing firm j will dedicate resources to theft and security. See figure 5. There, given that firm B is purchasing input amounts y_{1B}^{T*} for theft and y_{1B}^{S*} for security, the marginal returns to use of the input for firm A are equal whether used for production, theft, or security, and positive amounts of the input are used for each purpose.

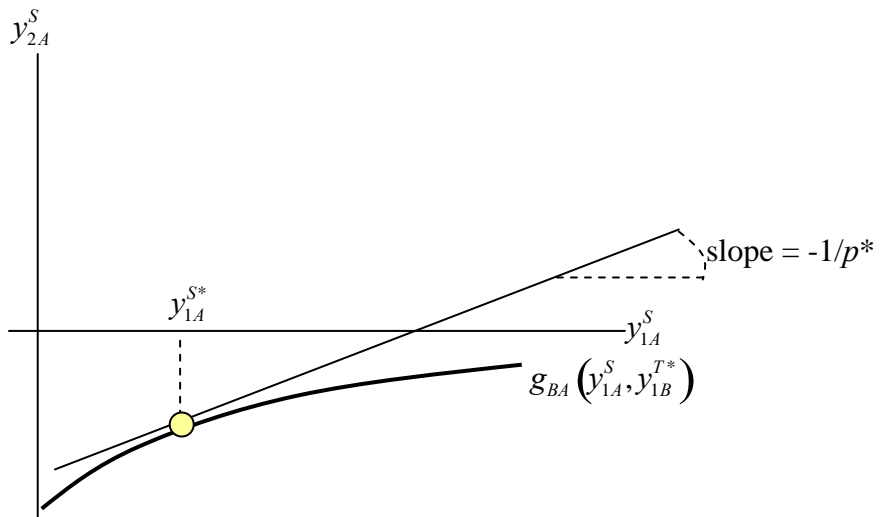
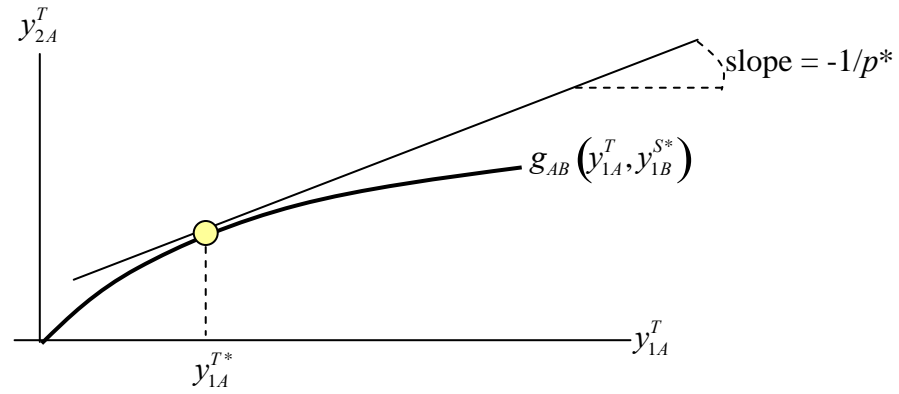
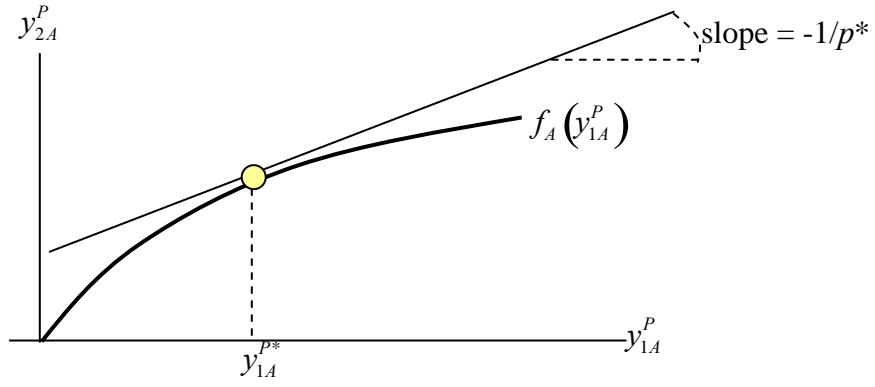


Figure 5. Profit-maximizing purchases of the input for production, theft, and security.

Is Equilibrium Pareto Inefficient when Property Rights Are Violable? If So, Can Government and Politics Fix It?

The economic literature on efficiency and government intervention is rather schizophrenic. On the one hand, there is a large literature about rent dissipation, which claims that the traditional Harberger dead weight triangles of government intervention only begin to account for its inefficiency, since lobbying efforts used by interest groups to secure favorable government intervention are in themselves wasteful. (e.g., Tullock 1967, 1980, 1984, 1985, 1987, 1989). A seminal political economy model (Becker 1983) often cited as a theoretical basis to believe in the efficiency of government policy, in fact has a Pareto inefficient equilibrium. Becker hypothesized intuitively that the government intervention we witness should be Pareto efficient, or else it would lose political support (Becker 1983). Yet, Becker's formal model is of a one-shot noncooperative game, and in fact its equilibrium is generally Pareto inefficient, as are many one-shot noncooperative games. A series of political economy models by Grossman and Helpman (see Grossman and Helpman 2001, chapter 7) are also noncooperative game models, but give one agent (the government) a first-move advantage, which provides the result that their equilibria are Pareto efficient. Numerous applied works in the agricultural political literature assume either implicitly or explicitly that government policy is Pareto efficient (see Bullock 1994, 1995, 1996). In the current paper, my aim is to begin addressing these seemingly contradictory results in the literature on the Pareto efficiency of government policy. I've tried to begin approaching this problem at its roots, by imagining a society even more primitive than the Arrow-Debreu economy.

When property rights are violable, do we expect a competitive equilibrium to take the economy to its Pareto frontier? The answer in general is no, not if people cannot manage to play some sort of cooperative game; theft and security result from noncooperative play from economic agents, and they waste resources. When resources are wasted, then the economy must travel to the interior of its utility possibilities frontier.

If everyone refused to steal, then no one would need security, and aggregate income in the economy would rise; but it may well be in each firm's private interest to invest in thievery, security, or both. This fundamental aspect of human society, that property rights are violable, is at least one of the forces that leads to the necessity of cooperation among individuals to form groups, and to cooperation among groups to develop the institutions that we call politics and government..

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