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Markets, Justice, and the Interests of Future Generations

ABSTRACT: *This paper considers the extent to which market institutions respond to the needs and morally significant interests of future generations. Such an analysis of the intertemporal effects of markets provides important ground for evaluation of normative social theories, and represents a crucial step toward the development of an adequate account of intergenerational justice. After presenting a prima facie case that markets cannot provide appropriate protections for future needs and interests, I evaluate and reject two of the most promising arguments that purport to rebut this case. None of these arguments is adequate to show that markets will protect the interests of future generations. Given important grounds for pessimism about non-market solutions, this leaves little room for hope that we can successfully preserve productive resources that future generations will need to satisfy their basic needs. However, I tentatively suggest where this hope may reside.*

ROLE OF MARKETS IN A THEORY OF INTERGENERATIONAL JUSTICE

Social institutions provide a framework that determines, in part, the shape of our society and the nature of the opportunities available to its members. But current political and economic institutions also will shape the society of our distant descendants, and our choices can open or close opportunities for them as well. To the extent that their opportunities and well-being are in our hands, shaped by the institutions we create and maintain, these distant future persons may well have morally significant claims on us. We must consider therefore whether

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our institutions suffice to meet the claims of the future, and in general we must ask whether there is any possible set of social institutions that could both provide for the legitimate claims and needs of present persons, while also giving future persons their due? This is a large question. A full answer would constitute a theory of intergenerational justice and would include careful consideration of at least two more restricted questions: First, what claims, if any, do the members of future generations have on us? Second, what arrangement of social institutions, if any, can respond appropriately to these claims without unjustifiably sacrificing the legitimate claims of the present generation? An answer to this second question will involve a careful examination of specific institutions, both political and economic.

In this essay I cannot develop a full theory of intergenerational justice.[1] But as an important step toward the development of such a theory, I will examine the largest and perhaps the most pervasive social institution on earth: the global economic market. I will consider the market's ability to provide for the basic interests of future generations. I will address the following question: If we accept, minimally, that it would be wrong for members of the current generation to do what would unnecessarily deprive future generations of the productive means to provide for their basic human needs,[2] how confident may we be that their interests will be protected adequately by the free operation the market?

It is perhaps surprising that so many philosophers and economists have argued that we should trust the market adequately to accommodate the interests of future generations. While we may have no illusions about the efficiency of bureaucratic management of resources, or the efficacy of most environmental regulation, we may be at least as skeptical of proposals that we should leave crucial resources at the mercy of markets. However, this is just what has been recommended by many theorists. Resource economists struggle to show that free markets will achieve at equilibrium the usage rates we would wish to command as social optima,[3] while Public Choice theorists argue that bureaucratic and political restrictions on the free operation of the market are unlikely to achieve their intended results. Advocates of "free market environmentalism" have claimed that the best way to solve our environmental and resource problems is to lower barriers to trade and to institute property rights in resources that are currently un-owned, or commonly owned. It has been suggested that we 'propertize' virtually everything, from coral reefs, to herds of migratory whales.[4] This portion of the case in favor of the market is especially important for libertarians, who must argue either that free markets will adequately accommodate the claims of the future, or else that the well-being of future generations is irrelevant for the theory of justice.[5] More important, an analysis of the intertemporal distributional effects of markets represents a crucial step toward the development of an adequate theory of justice between generations.

In this essay, I review briefly a general account of market efficiency, and construct a *prima facie* argument against the market's ability to provide for future interests. Then I consider what I believe to be two of the most important arguments

that purport to rebut this *prima facie* case. First, I discuss Harold Hotelling's theory that market forces will promote optimal rates of resource consumption. Then I consider the popular argument offered by many economists and political theorists, that substitute technologies, called into existence by market demand, will solve problems of resource depletion. If I am correct in thinking that neither of these arguments is successful, this has important implications for the evaluation of our social institutions and for the theory of justice.

PARADISE

Economists often describe the conditions of perfect competition as a kind of economic paradise which can only be approximated in the relative purgatory of the real world. The well-known *first theorem of welfare economics* states that under conditions of perfect competition, markets will move toward pareto superior distributions, which are better for some and worse for none, and that at equilibrium, they will arrive at a pareto optimum from which it is impossible to make any individual better off except at cost to others. In what follows, I will describe an idealized situation in which markets really will produce desirable consequences. Later, I will relax some of the conditions of this economic paradise, to make it reflect more accurately the situation of the real world. Those who are suspicious of the assumptions of economic theory may not be comfortable with the description that follows. However, my argument should be of interest even to such skeptics. What I hope to do is to grant advocates of the market those assumptions most propitious for the case that is needed. If markets are not likely to achieve desirable results even under ideal circumstances, this provides the strongest argument against the claim that they will do so in the real world.

In this interest, consider an isolated two-person economy, in which the participants, Eve and Adam, mutually have recognized property rights in two different kinds of productive resources: manna-producing fields and wood-producing forests. The initial endowment of each is a mixture including both field and forest, and each needs manna to eat and wood to burn during the cold Eden winters (departing somewhat from the biblical account). However, neither Adam nor Eve is fully self-sufficient; each year, Adam's fields produce insufficient manna to meet his needs, while his forests produce more wood than he can use. Eve has a similar problem; her forests produce too little wood to keep her warm, while her fields produce more manna than she can eat. Clearly, Eve and Adam can make a mutually advantageous arrangement: Eve can trade her surplus manna for Adam's surplus wood, and both will be better-off as a result. The standard theory predicts that they will trade wood for manna until they reach an allocation that is pareto optimal—that is, an allocation from which neither can be made better off without cost to the other.

It will be valuable to have a more formal model of the situation described. For the purposes of this model, I will assume that Eve and Adam have preferences

which fit the model of rational agents given in current microeconomic theory. Specifically, I will assume that the structure of their preferences over wood and manna can be captured accurately by indifference curves, representing the rate at which Eve and Adam are willing to trade one of these commodities for another. In Figure 1, each point represents an allocation of manna and wood, and the curves that are convex with respect to the origin are Adam's indifference curves. Adam is indifferent between allocations that lie on a single curve, but prefers allocations that lie on indifference curves which are 'higher' to those which are lower[6] (Figure 1).

Eve's preferences can be represented similarly. Combining the two, we can represent the entire two-person economy in the context of an Edgeworth box (Figure 2).

Figure 2 represents a two-person "market" with two commodities—wood and manna.[7] Every point in the matrix represents an amount of wood and manna produced by the economy in a given period. The indifference curves $\ldots a_n \ldots a_{(n+1)} \ldots$ that are convex with respect to the origin represent Adam's preferences over wood (horizontal axis) and manna (vertical axis), while Eve's indifference curves $\ldots e_n \ldots e_{(n+1)} \ldots$ are concave with respect to the origin. Rectangle AMEW is thus an "Edgeworth box," showing their initial allocation of wood and manna at point x. From x, both Eve and Adam prefer allocations that lie within the lens, the disk-shaped area defined by the indifference curves passing through x. So if nothing

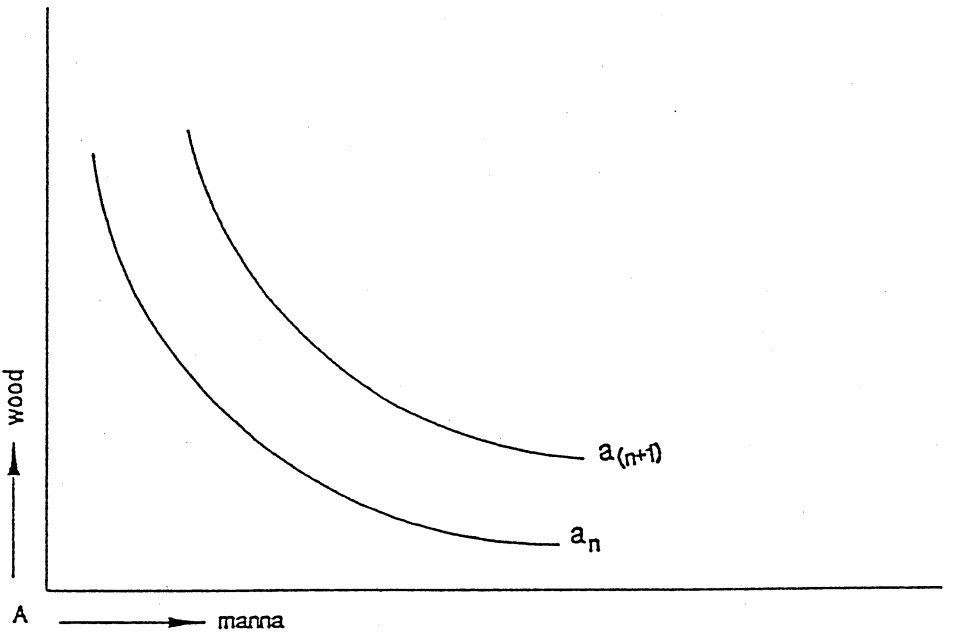

Figure 1.
Indifference curves over wood and manna.

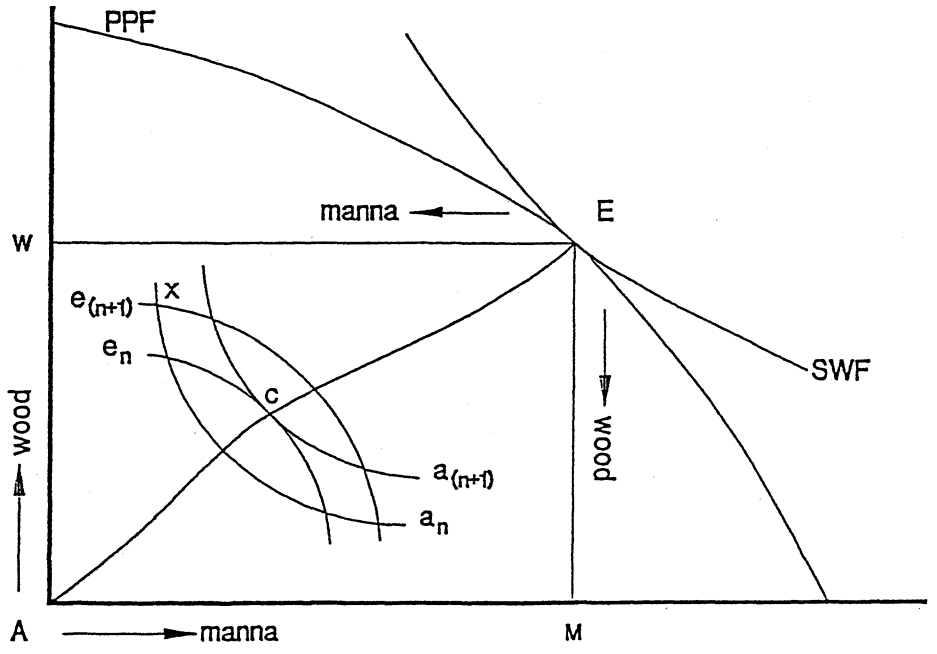

Figure 2.
Single-period model of the economy of Eden.

prevents them, they will trade wood and manna, and both will benefit. At point *c*, their indifference curves are tangent to one another: there is no lens. Since from *c* there is no way to reallocate resources that will move one to a higher indifference curve without moving the other to a lower, *c* is pareto optimal. The collection of all pareto optimal allocations can be represented by a line *AE* (not necessarily a straight line), running from the south-west corner of the box to the north-east corner.

This simple model can be expanded to include the productivity of the economy. Suppose that Eve and Adam have different productive options, and that their choices include not only the way they will trade with one another, but also their allocation of labor. While total labor time is fixed, each can choose the proportion of that total to be put into fields and forests.[8] In Figure 2, the production possibility frontier (PPF) represents the set of maximally productive choices available. From a point on the PPF, it is impossible for the economy to produce more manna without diminishing the production of wood, and vice versa. Since each point on or within the PPF represents a possible production rate for this economy in a given period, it is possible to find an Edgeworth box for any point on or within the PPF. The production point *E*, which specifies the amount of manna and wood available for trade for this period, is not chosen by either Adam or Eve, rather it is a function of the production choice of each. In deciding how much to produce, they will consider both the amount of each commodity needed (or wanted) in this period, and

the amount she can expect to get by trading with the other. As long as both choose strategically, the economy will achieve a distribution on, rather than within, the PPF. For example, if it is in general more costly for Eve than for Adam to produce manna, and more costly for Adam than for Eve to produce wood, then Eve will produce more wood than she would prefer to consume, planning to trade her excess wood for Adam's manna. In general, whoever has lower marginal production cost will choose to produce until marginal costs are equalized. Consequently, the economy will follow the law of comparative advantage and will be maximally productive. If we could construct a social welfare function (SWF) for this economy (and this will not always be possible for larger economies), the free interaction of the participants would result in the choice of a "socially optimal" production point on the PPF where the SWF is tangent.

The model I have roughly sketched here describes what some regard as the most important result of contemporary economic theory. David Gauthier writes:

> The great discovery of our society is, of course, the discovery of the social value of self-interest. The triumph of the science of economics was to demonstrate that under appropriate conditions, those of perfect competition in a free market, if each person acted purely self-interestedly, to maximize his own utilities, then the outcome would necessarily be optimal, the particular optimum depending solely on the initial positions of the persons in the market. Instead of repressing self-interest, our society has harnessed it. The benefits have been striking; critics of our society would argue that the costs have been overlooked.[9]

One often finds arguments of the following form offered by theorists less careful than Gauthier: Since (i) core allocations are pareto optimal, and (ii) without interpersonal comparisons of utility, pareto optima are the best index we have to utilitarian maximization of well-being,[10] and finally, (iii) when markets are free and perfectly competitive, they will reach core allocations, it follows that if we want to promote human well-being, we should endeavor to make real world markets more closely approximate the conditions of perfect competition. When trade barriers are minimal, it is argued, everyone will be better-off.

In criticizing arguments of this sort, there are a number of strategies available. One might question the premise that interpersonal comparisons of utility are impossible—VonNeumann/Morgenstern utility functions do not support such comparisons, but other economic measures of human well-being do considerably better (see Crocker, 1992; Sen, 1985, 1992; Nussbaum, 1992). Alternately, one might question the relevance of a model that requires perfect information, and assumes away economic externalities. Such a model seems otherworldly in circumstances like our own, where externalities are the rule, not the exception (Daly, 1994). One might also question the normative force of the pareto criterion, since some pareto optima will be marked by of radical inequality. But these strategies have been investigated thoroughly by defenders and detractors of the market. In the following sections, I will take a different tack. I will argue that the model of perfect competition does not adequately account for the interests of the future, and

is therefore unacceptably atemporal. In the following section, I present a *prima facie* case in favor of this claim.

EXTENDING THE MODEL OVER TIME: PARADISE LOST?

So far, our model describes the workings of a tiny economy within a single production period. In extending the model over time, assume that production periods are discrete. Each year, Eve and Adam choose what they will produce, and plan to trade with one another to achieve an optimal distribution. The economic activity of each period can be represented by a production point, an ini-

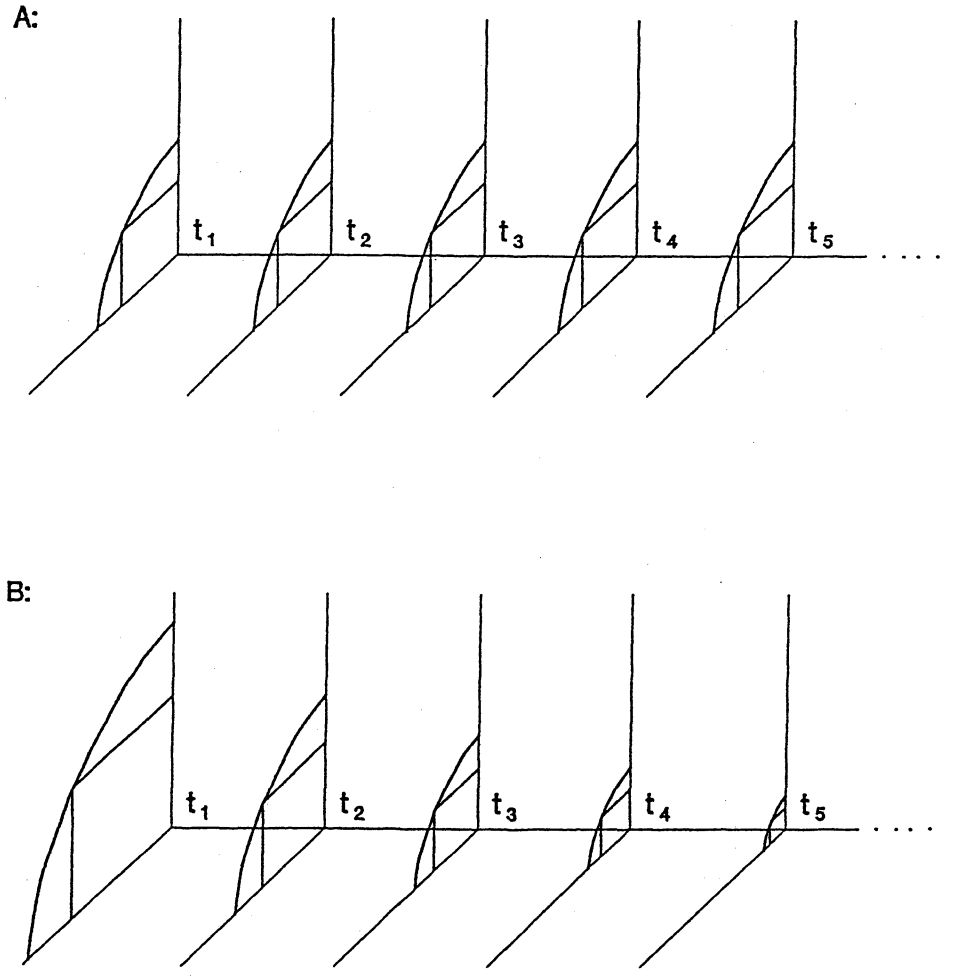

Figure 3.
Production possibilities over time: sustainable v. unsustainable production in Eden. Curved lines represent production possibility frontiers in successive time periods from t_1 to t_n.

tial allocation, and a set of pareto optimal points which can be achieved by trade. Assume also that manna and wood rot between periods, so that neither person can store supplies for the future. Over the course of successive periods, the economy can be represented in a three-dimensional graph, as shown in Figure 3A.

In each period, Eve and Adam choose their respective production levels and trade to achieve an optimum. However, the series of optimal distributions they achieve can be evaluated itself. For example, it would be undesirable if the PPF shrank in each successive period, as shown in Figure 3B. But the terms used so far to describe the economy provide no ground for criticizing such steady decline. It is possible for the economy to reach a pareto optimal outcome in each period, and yet for the succession of optima achieved to represent ever-declining production, moving toward famine and want. To see this more clearly, consider the extension of our simple model: Initially, Eve and Adam have both fields and forests. Over time, they must reserve some manna from each year's harvest for the following year's planting and must leave some wood in the forest for next year's harvest. But suppose that they have another alternative. Suppose that the resources they possess can produce at a higher rate, but that this increased production has a cost. It will degrade their resources, and after ninety years, productivity will rapidly dwindle toward zero. They need to choose whether to reap a relatively short term gain for long-term cost. For simplicity, suppose that the choice in the first period will determine the pattern of production and consumption to be followed over the next ninety years. Should economically rational Eve choose (A) to endure a lower level of production and consumption that doesn't degrade productive resources, and which can be sustained indefinitely, or (B) to enjoy ninety years of increased prosperity with the costs described?

Clearly, sustainability[11] should be preferred to unnecessary depletion. The question then is, what conditions must be added to this description of the economy of Eden to make it rational for Eve and Adam individually to choose sustainability? Two conditions might be sufficient. First, they must expect to be around to endure the resultant hardships if they choose A. Second, they must not discount future payoffs heavily. But when the consequences of our choices extend into the distant future, the first condition implies virtual immortality.[12] Those who make analogous choices in the real world are not immortal, and they most certainly discount future eventualities.

Perhaps there are alternate assumptions capable of guaranteeing that the economy of paradise will include adequate incentives to guard the interests of the future. If Eve and Adam exchange more than just wood and manna, they may have children who would benefit from conservation, and if they care enough about their children's welfare, they will have reason to avoid production levels that would deplete their resources. But even if Eve and Adam *do* care about their children's welfare, this by itself may not be sufficient to guarantee that they will not rationally choose to deplete, for some damaging consequences of our current choices may not bear bitter fruit for several generations. If the devastating effects of current

overproduction will not occur for a number of generations, but the productive benefits will be enjoyed for several generations to come, then concern for immediate descendants could provide a motive to deplete rather than to conserve. If it is assumed that concern for immediate descendants is likely to exceed concern for more distant descendants who can never be met, and who may (for all we know) not come into existence at all, then even parental concern and affection may not provide an adequate motive for the conservation of productive resources.

The first theorem of welfare economics tells us that a perfectly competitive market will achieve an optimal distribution of resources, but even if markets achieve pareto optima at every point in time, this gives us no reason to think that the succession of optima achieved will itself constitute a desirable intertemporal or intergenerational distribution. Without considering the effect of a given momentary "optimal" rate of production on the intertemporal production stream (specifically, the possibility that current production may limit future production possibilities), we cannot know whether current production is consistent with intertemporal sustainability, even when it would be possible to sustain a very plentiful production stream. There has been much discussion among political philosophers and social scientists of market failure, of the problems associated with public goods and externalities, and of the potential inequality of pareto optimal distributions. But even if these problems could be solved adequately, this intertemporal problem would remain to undermine the claim that synchronic market optima are desirable. The problem is not simply that real markets won't achieve "optimal" distributions, but that the conception of optimum employed is too narrow to allow intertemporal and intergenerational comparisons across long periods of time. One clear minimal standard we should adopt for an acceptable intertemporal distribution is this: if it is feasible to achieve a production stream that both (i) meets present needs, and avoids infringing the valid claims of members of the current generation, and (ii) avoids compromising the productive opportunities of future generations such that they will be unable to meet their basic needs, such a production option must be preferred to production streams that tend toward depletion and deprivation. But the standard of pareto optimality gives us no reason to prefer sustainability over steady decline, and in fact, sustainability may be inconsistent with the achievement of momentary pareto optima. Even those who recognize that the pareto criterion has limited applicability typically have not discussed these intertemporal limitations.[13] However, there have been attempts to extend the theory of markets over time. A number of economists and philosophers have argued that the terms of free interaction in the context of competitive markets will ensure that resources will not be overexploited, and that future generations will have adequate productive resources to satisfy their needs. In the remainder of this article, I evaluate several arguments which have been taken to support the claim that markets will produce desirable intertemporal results.

FIRST ARGUMENT FOR THE MARKET

Hotelling on the Optimal Intertemporal Use of Nonrenewable Resources

Although economic theory has changed a great deal since 1931 when Harold Hotelling's famous paper on exhaustible resources appeared, his work still represents a cornerstone of what may be called the received view.[14] Hotelling's aim was to show that monopolists who have control of a stock of a nonrenewable resource (such as coal or oil) have a strong motivation to conserve their resource in the interest of keeping the price high, and maximizing overall profit.[15] But many economists have taken other aspects of this model as more centrally important than this point. Implicit in Hotelling's analysis is a concept of intertemporal efficiency and an argument to the effect that free markets with enlightened monopolists in control of the stock of nonrenewable resource should be expected to reach allocations that are not only intertemporally efficient (by itself quite a weak requirement), but which also effectively respond to social need. If Hotelling is correct, they will do this without taxation or regulation.

Since a rational monopolist will want to introduce a product into the market in a way that will maximize total profit, she will want to sell when price is high, and the extraction cost low. Over time, the supply of any nonrenewable resource will diminish, and as it does so, price will rise. So the rational monopolist will wait to realize the greater profits to be achieved later. For example, at every point in time, and for each unit of resource extracted, a mine owner has a choice either to extract and sell the ore, or to leave it in the ground, where its value will appreciate at the market rate as scarcity increases the market price. If extracted, the profits could grow at the market rate of interest. So the owner is best off extracting ore only to the point that the rate at which its market value increases equals the market rate of interest. As Talbot Page characterizes this view, "Future scarcity, reflected in the expectation of higher future prices, leads each mine owner separately to act like a conservationist in order to maximize the present value of his profit stream."[16] But this result can be approached from the perspective of social benefit as well as the perspective of individual profit maximization on the part of the mine owner.[17] In this interest, Hotelling calculated the present value to society of the stream of resources flowing into the economy from a mine controlled by a rational monopolist. Because high prices reflect the needs of consumers, it is *socially optimal* to release the resource when consumer need (and therefore price) is highest. Monopolistic mine owners, in the interest of maximizing their own profits and not from any altruistic conservationist motives, will release their resources during times of greatest social need. When this happens, markets will achieve an intertemporal Hotelling-optimum.

In fact, Hotelling argues that the problem faced in a competitive economy is not that of over-exploitation of resources, but of under-exploitation. Those who control resources have a strong motive to release them at rate *below* the social opti-

mum. In part, this is simply "part of the general tendency for production to be retarded under monopoly."[18] But even if monopoly is imperfect, and there is a small number of independent mine owners, these problems can still arise:

> [In a market with a limited number of sellers and many buyers,] if one seller increases his price moderately, thus making some immediate sacrifice, the other will find his most profitable course to lie in increasing his own price; and then, if the original increase is not too great, both will obtain higher profits than at "equilibrium."...With an exhaustible supply, and therefore with less to lose by a temporary reduction in sales, a seller will be particularly inclined to experiment by raising his price above the theoretical level in the hope that his competitors will also increase their prices. For the loss of business incurred while waiting for them to do so he can in this case take comfort, not merely in the prospect of approximating his old sales at the higher price in the near future but also in the fact that he is conserving his supplies for a time when general exhaustion will be nearer and even the theoretical price will be higher. Thus a general condition may be expected of higher prices and lower rates of production than are given by the solution of the simultaneous characteristic equations [i.e. at the social optimum].[19]

Rather than a problem of over-exploitation, Hotelling's model supports a prediction that we won't use our nonrenewable resources fast enough. If so, it might be economically optimal for the government to subsidize *consumption* to keep the market price artificially low! If the Hotelling model is right, then conservationists, far from serving the interests of the public or future generations, are merely dupes helping resource owners to maintain their monopoly rents.

More than sixty years after the publication of Hotelling's analysis, many discussions of resource economics end with a presentation of his argument, taking it to have shown that, provided that a properly functioning price mechanism exists, society does not need to make any provisions for future generations, "either in respect of wealth in general, or in respect of finite resources in particular."[20] But one might be unconvinced for either of two reasons: if Hotelling's argument fails, it must either be (i) because his account of 'optimum' is too weak to carry normative force, in which case the achievement of a Hotelling-optimum may not be a desirable goal, or (ii) because the conditions of the actual world are importantly misrepresented by the assumptions of his model, in which case we may have no reason to believe that markets will achieve Hotelling-optima. I will argue that Hotelling's model fails in both respects.

(i) Hotelling-optima may not be socially desirable. According to Hotelling, greatest consumer need is represented in high prices, and since a rational monopolist will hold out for the highest prices, resources will be conserved, and released during times of greatest economic need. One initial problem is elemental: since social need is only one among many determinants of price, price is not an adequate indicator of social need. Price is determined by demand, which reflects people's willingness to pay for what they need. But from the fact that a destitute population is "unwilling" to pay much for bread, it would be absurd to conclude that they don't need it. The point is a familiar one, and indeed it applies to present-time cases as well as to cases for which production is extended in time.

But if there is a general expectation that depletion will eventually leave people worse off (as Hotelling explicitly assumes), then the problem is exacerbated in the intertemporal case. If Hotelling's 'enlightened monopolists' expect the economy to be weaker in the future than in the present, they should expect prices to fall, not because people need resources less, but because people will be unable to pay for what they will need. In such circumstances, profit will provide no overriding motive to conserve but rather a motive to unload resources into the market as quickly as possible to avoid the lower prices they will command later. In such circumstances, individual owners might wish to hold resources back to avoid flooding the market, but unless resource owners can solve the collective action problem, it is unlikely that they will succeed. For even though it is in the interest of each to hold resources back, the market may punish those who do so, since those who hold goods back from the market may have to sell them later, when the market is weaker. Hotelling's assumption that later prices would be higher after scarcity sets in is based on an assumption that overall economic prosperity will not suffer as resources dwindle. If one wanted Hotelling's theory to provide support for the claim that markets will insure future prosperity, one will be disappointed to find that his model assumes without argument what one hoped that it would show.

If enlightened monopolists believe, as Hotelling did, that the world is destined to run out of resources, then they may have no good reason to conserve resources for later consumption. Markets would still achieve a Hotelling-optimal intertemporal distribution, since monopolists would sell when overall expected returns are greatest. But clearly this undermines any claim that the Hotelling-optimum represents a socially desirable intertemporal distribution.[21]

(ii) Markets will not approach Hotelling-optimal distributions as market conditions more closely approximate the model of perfect competition.[22] There are at least three reasons for this. First, the value of an untapped resource depends partly on the market price it can be expected to command, but also on the current 'price of money': the interest rate. If the rate at which one's resource is gaining value is less than the market rate of interest, then one would do better to extract and sell the whole thing immediately, and put one's money in the market.[23] But second, this initial problem may be exacerbated, since the value of money *to an individual* will vary depending on a number of factors Hotelling does not discuss. Hotelling's model works only if the problem facing a resource owner is maximizing the total present value of the resource. He explicitly assumes that people will be indifferent between a payoff p at time t, and a market adjusted payoff of $p(1+\pi)^n$ *at time* $t+n$, where π represents the market rate of interest.[24] But the problem of resource use over time is a problem for which the time horizon may be very distant. People's needs change over the course of their lives, and it is unlikely that real people are indifferent between market-adjusted payoffs that arrive at different times. The market interest rate represents the value of money within the economy, but individuals must consider their own *internal* interest

rates, representing the value of money *for them.* The value of a dollar *to an individual* is likely to be quite different at different points in life, and these differences will not reflect the market rate of interest or the market price of holdings. The same is true of firms, in part because firms are run by individuals, but also because firms have different economic needs at different times (dependent on debt profile, for example). As the value of money to a firm (the 'internal' interest rate) changes over time, so the motive to conserve or sell resources changes. To the extent that the choices of monopolists are informed by such factors, market allocations will diverge from the intertemporal Hotelling-optimum. Given the importance of debt in the context of institutional choice, there is good reason to believe that this divergence will be considerable.

There is an even more important (third) reason why markets will not achieve Hotelling-optima. As noted above, a Hotelling-optimum will be achieved only if maximization of present value to individuals is the same as maximization of present market value. But when decisions involve time horizons that are many lifetimes away, personal and market values will diverge radically: people are *mortal,* and they generally care less about benefits that will be enjoyed after they have died than they do about those they will be there to enjoy for themselves. While firms may be longer lived than individuals, those who make decisions within firms are mortal individuals, who may choose policies with their own interests in mind. To the extent that our theories ignore this fact, we should expect their predictions to fail. Corporate managers often need to prove themselves quickly in order to keep their positions, and this may lead them to prefer short-term profit over the long-term interests of the firm. It is (plausibly) assumed that individuals discount payoffs that arrive later in their lives, this will make it even less likely that firms will make choices in the way Hotelling describes. If we assume further that people tend to place higher value on payoffs received *ante mortem* than those received *post mortem,* this strengthens the case for the prediction that real-world resources will be consumed faster than Hotelling's model would recommend.

Hotelling's brilliant argument cannot be taken as an adequate defense of the market. What Hotelling has shown is that there are conditions under which highly idealized markets will reach a kind of intertemporal optimum. He has not shown that these optima represent a desirable intertemporal distribution, nor that the conditions of the real world are such that we should expect our markets to reach these optima.

SECOND ARGUMENT FOR THE MARKET

Supply, Demand, and Substitution

Hotelling believed that the world was eventually destined to run out of resources. The problem, then, was to find a way to use those resources in a way that would be most likely to produce the greatest utilitarian total of human

felicity. But some contemporary economists and political theorists claim that we will never run out of the resources we need.[25] As long as the competitive price system is functioning adequately, increased consumer needs will create economic circumstances propitious for the development of new technologies, to replace finite resources as they are depleted. The basic idea is this: as a valued resource *r* becomes increasingly scarce, its price will initially rise. When this happens, producers who use *r* to make their product have an economic motive to search for some way to do without *r*, either by finding some alternate substance that works almost as well, or by finding a way to bypass a step in their manufacturing. The result of scarcity then, is an economic environment that rewards certain kinds of technological progress. Here is a concise and fairly representative statement of the view:

> ...it makes little sense to speak of the country or the world as "running out" of energy. When the supply flow thins, prices increase, consumption declines, and, aided by new technology, the supply of the commodity in question, or a workable substitute, increases. A new equilibrium emerges at which supply and demand are brought into balance at a higher price.
>
> Thus the world will not run out of oil, but it will have to pay more for it. As oil becomes more costly to find, extract, and transport from remote places, its use will decline. Customers will abandon it for other sources of energy, or use less energy altogether by substituting other goods (blankets, insulation), or both. Oil will continue to be used by those who value it enough at the higher cost not to go without. It pays them to buy at the higher price. If the market works—a proposition one should not take for granted—the transition should not be too painful and petroleum will be used efficiently, that is, in uses where it has the highest value to the user.[26]

Like Hotelling's theory, this Optimistic View implies that there is no need to take steps to protect the interests of future generations, because unfettered markets will do this by themselves. Needs will be reflected in consumer demand, demand will create incentives, and individuals will respond to these incentives by producing substitute technologies capable of responding to needs. The authors comfort us by assuring us that new equilibria will continue to emerge even though the price of finite resources may rise. But reflection on the nature of such equilibria undermines any comfort this might seem to provide. After all, there are describable equilibria at which there is widespread famine and want. If we are interested in the markets' ability to provide for basic human needs, we need to know more characteristics of the equilibria to be achieved.

Julian Simon's famous argument that our resources are infinite is an attempt to support the hopeful conviction that the equilibria reached will not be characterized by famine or want. Simon famously (or infamously) argues that the notion that we may run out of resources is based on a false conception of the term "finite":

> The word "finite" originates in mathematics, in which context we all learn it as schoolchildren. But even in mathematics the word's meaning is far from unambiguous. It can have two principal meanings, sometimes with an apparent contradiction between them. For example, the length of a one-inch line is finite in the sense that it is bounded at both ends. But the line within the endpoints contains an infinite number of points; these

> points cannot be counted, because they have no defined size. Therefore, the number of points in that one-inch segment is not finite. Similarly, the quantity of copper that will ever be available to us is not finite, because there is no method (even in principle) of making an appropriate count of it, given the problem of the economic definition of "copper," the possibility of creating copper or its economic equivalent from other materials, and thus the lack of boundaries to the sources from which copper might be drawn.[27]

Perhaps line segments can be infinitely divided in this way, but can resources? Herman Daly compares Simon's argument to Zeno's paradoxes:

> It would be a wonderful exercise for a class in freshman logic to find the parallel between Simon's argument and Zeno's paradox of Achilles and the tortoise. Recall that Zeno "proved" that Achilles could never catch up with a tortoise that had a finite head start on him. While Achilles traverses the distance from his starting point to that of the tortoise, the tortoise advances a certain distance, and while Achilles advances this distance, the tortoise makes a further advance, and so on, *ad infinitum*. Thus Achilles will never catch up.[28]

Since the development of the calculus, we now understand the fallacy behind Zeno's argument: sometimes an infinite series of increasingly smaller units does sum to a finite quantity. Since the series of progressively smaller distances that Achilles must advance is a geometrically decreasing series, its members sum to a finite limit. The situation is the same in the case of the increasingly smaller segments of Simon's one-inch line, and also with our decreasing stocks of exhaustible resources. Achilles eventually will catch his tortoise, and we eventually will reach the limit of our resources, as Daly might argue.

Surely the amount of copper that exists is finite in many important ordinary senses. For example, there is some finite (though unknown) number that accurately represents the mass of all the copper in discovered and undiscovered deposits on our planet. Has Simon foolishly stumbled over Zeno's fallacy? Perhaps not. It will be valuable to present a sympathetic a reading of his argument from the start. In this interest, note that there are two ways in which our finite stock of resources may be "infinitely" expanded. First, we might try to divide it into and infinite number of smaller and smaller finite units, like Simon's one-inch line and like the infinite number of increasingly small distances Achilles must cross if he is to reach the tortoise. As Daly notes, this will not be sufficient to stretch our resources literally to infinity. The functions used in many economic models assume infinite divisibility of money and resources, but actual resources are unlikely to cooperate with such assumptions. Geometrically decreasing supplies really do go to zero in the non-ideal world of concrete resources. It is difficult to believe that the members of any later generation will be able to support their energy needs with a single molecule, and the problem they leave for their descendants will be even more perplexing. And we will not be mining *copper* any more if we reach the point at which there is only one molecule left to exploit.

Simon may be right in thinking that we will never reach such a point. For there is a second way to extend our resources: we can use our creativity and imag-

ination to invent new technologies that will replace resources as they become scarce. In the second stage of his argument, Simon suggests that we should redefine "copper" according to economic criteria rather than according to chemical composition. It is on this point that the strength of his argument depends. Simon recommends that we adopt functional definitions for the resources we consider to be 'finite'. That is, for the purposes of social policy analysis, resources should be defined according to the services and benefits we receive from them rather than by their chemical composition. So defined, argues Simon, the extent of our resources is limited not by their physical mass, but only by our ability to develop substitutes capable of serving the same functional role as the resources we currently use. If "copper" is defined in terms of the functional uses for which we currently *use* the metal *Cu*, then "copper resources" are limited only by our inventiveness in discovering new materials to use as conductors (perhaps alternate metals) or developing alternate technology which doesn't require conductors (like fiber optics), as well as alternative materials to use in place of copper in other contexts in which it is currently used.

There is no easy way to measure or to predict accurately the ability of human innovation to create substitutes. Simon explicitly assumes as a premise of his argument that if prices for resources rise, economic motives will in fact inspire people to look for substitutes, and that they will in fact find them, provided only that they have proper economic motivation. He raises this assumption to the status of principle: the "principle of infinite substitutability" is the "principle" that our ability to discover substitute technologies is only as limited as human imagination and creativity. But Simon claims that human imagination and creativity is limitless. It follows, he believes, that our ability to generate substitute technologies must be similarly limitless. And from this claim, it follows that our resources, functionally defined and bounded only by our unlimited creativity, are also infinite. Q.E.D.

Since this Optimistic View is advocated widely, it is important to recognize the kernel of truth that generates it as well as its limits. There are some reasons for optimism: scarcity and consumer demand will not only raise the price of resources, but often will provide incentives for the invention of substitute technologies to functionally replace resources as they dwindle. The kernel of truth is that technology can extend our resource base, and scarcity may provide an incentive to prompt the creation of such technology. The limit is less clear, but not less real: we really cannot predict the extent to which technology will succeed in providing adequate low-cost substitutes, and incentives are not always sufficient to prompt people to solve practical problems as they arise.

In general, there are three ways in which technology can extend our resource base. First, technology can help us to find better, cheaper, more efficient ways to discover and extract existing resources (efficient coal-digging machines that won't destroy the countryside). Second, it can help us to use our resources more efficiently (more miles per gallon of gas). And finally, technology can help us by offering real substitutes for resources we currently use (hydrogen or solar cars

instead of gas guzzlers). Obviously, increased efficiency in extraction will not increase the size of a resource and ultimately cannot support the claim that our energy base is infinite. But if the efficiency of technology were to increase exponentially, so that each generation could afford to use (and actually did use) only half of the total amount of fuel used by the previous generation, then in theory we would never "run out," since use rates could then decrease exponentially. But exponentially increasing efficiency, even if we could achieve it, really could not go on forever. The functions used in many economic models assume infinite divisibility of money and resources, but actual resources are unlikely to cooperate with such Optimistic assumptions. Geometrically decreasing supplies really do go to zero in the non-ideal world of concrete resources. It is difficult to believe that the members of any later generation will be able to support their energy needs with a single molecule, and the problem they leave for their descendants will be even more perplexing. The Optimistic View does, then, ultimately depend on faith in technology and human creativity, and their ability to respond effectively to economic incentives. What is the connection between needs, incentives, and the development of needed technologies?

As one might expect, the connection is not straightforward. First, and as pointed out earlier, economic incentives may not be aligned with human needs. In our world, need and market demand diverge in predictable ways.[29] Second, Optimism is justified only when technological solutions are possible. This possibility may be limited by the bounds of human creativity or by natural physical laws. We are justified in considerable optimism about the fruitfulness of human creativity; the past century has seen an expansion of technology unprecedented in the history of the world. But it would be hubris to suppose that this capacity is unlimited in its ability to provide future generations with what they will need, and that there is therefore no current need to concern ourselves with their interests.[30] No matter how great the economic incentives are, no one is likely to find a way to square the circle, or to travel back in time. Economic incentives can motivate people to try to perfect cold fusion, but these incentives do not guarantee their eventual success. It would be appropriate to adopt a more moderate understanding of the relations between incentive, creativity, and technology. I suggest the following as an improvement on Simon's excessively Optimistic View:

> When social and environmental needs are aligned with market incentives, the effects of market demand may increase the probability that technological solutions will be found for social and environmental problems that arise.

We cannot say that such conditions *guarantee*, or even make it *probable* that solutions will be found, only that it increases the probability. The degree to which this probability is responsive to incentives depends on other contingencies, like the fortunes of human creativity, the existence of a research and educational infrastructure to train technologists, the availability of materials necessary for the production of substitutes, and the cooperation of natural laws.

If we wish to take seriously the moral claims of future persons and to give them their proper weight, how should we regard this Optimistic View? Even if we have great faith in human imagination and firm belief in the necessity of technological advance, it seems excessive to place infinite or absolute trust in our ability to techno-think our way out of any resource scarcity we may bring upon ourselves. It is easier, for example, to imagine that technology may enable us to develop substitutes for copper than to imagine substitutes for clean air. If there are some things we cannot do without, and for which we cannot reasonably expect to find substitutes, the Optimistic View provides us no good reasons to leave their provision at the mercy of the market.

There is another important variable missing from the argument for the Optimistic View, with its great faith in human ability to produce technological substitutes—often technological "solutions" bring unanticipated problems. In developing his technological substitute for the horse drawn carriage, Henry Ford cannot have imagined that his efforts would ultimately create serious smog problems in Los Angeles and Mexico City, or that it would lead to destructive oil spills throughout the world's oceans. Substitute technologies represent a net gain for human society only if the problems they solve are more extensive and serious than the new and often unanticipated problems they raise. Many defenders of the Optimistic View focus exclusively on the benefits of technological advance and entirely ignore the difficult problem of comparing these prospective benefits against the unanticipated costs they bring.

One aim of the Optimists is to respond to naive catastrophist predictions that simply make estimates of the stock of resources and project the amount of time left for civilization if we maintain present usage rates. They are right about this: if projections of future resource requirements and availability do not include some consideration of the ways in which this resource base can be extended, then their predictions will be flawed. But if the argument really does boil down to a simple prediction that technology and human ingenuity ultimately will be capable of solving all of our resource and environmental problems, it is surely too weak to bear much weight. As Russell Hardin (1991) notes, we leave our descendants a mixed legacy: it does include the benefits of technological progress, an impressive system of roads and cities and power lines, and a set of highly refined social and cultural institutions. But it also includes the heavy costs of environmental degradation, depleted resource stocks, hard-to-kill bureaucratic swamps, and a variety of highly contagious social conflicts and ethnic rivalries. In considering whether the costs we impose on them are outweighed by the benefits, it is not enough simply to profess confidence in the "infinite substitutability" of resources, and the "infinite" scope of human imagination and adaptability. People are creative and adaptable. Maybe these natural assets will enable them to thrive even if the world we leave them is filthy, lifeless, and depleted. Optimists like Julian Simon and Jan Narveson are confident, willing to wager the well-being of the future that our descendants will be able to techno-think their way out of any problems we leave for them. It

seems unlikely, however, that our distant descendants would take much comfort in Simon's optimism.

INTERGENERATIONAL JUSTICE AND HOPE

"Two dead ends, and still you've got to choose..."—*Tom Waits*

It would be wrong to do what would deprive the members of future generations of the productive means to provide for their basic needs, at least if we can avoid doing so without excessive imposition on the needs, or violation of the rights of members of the present generation. Similarly, it would be wrong to support and maintain institutions that may unnecessarily leave the future in this tragic predicament. I would argue in addition that to do so would be unjust, though I cannot adequately support that claim here. Even those who accept that we ought, morally, to leave the members of future generations adequate means to provide for their needs, cannot conclude from the argument given here that it would be wrong to support and maintain market institutions. One reason for this is that there are still other models for intergenerational market efficiency which have not been discussed here.[31] Another important reason is that alternatives to the market may be unlikely to do any better: while one may have deep reservations about markets, it remains to be shown that there is a viable alternative that is *more* likely to provide for the relevant interests of future generations. Public choice theorists have argued that political constraints on market freedom are often ineffective, and others convincingly argue that such constraints often represent oppressive restrictions on individual liberty. To the extent that discussions of intergenerational justice ignore these problems, they will appear naive and ill considered. Acceptable accounts of justice between generations must incorporate neither wide-eyed faith in the efficacy of political solutions, nor wild-eyed optimism about the market's ability to provide for the fundamental interests of the future. Perhaps we are stuck in the purgatory of reality, where we cannot do without markets, but where it may often be appropriate to limit the excesses of the market by conserving crucial natural and biological resources, and by protecting them from free market forces. Environmental legislation may often fail, but in the context of environmental protection and resource conservation, it has a better track record than the free market alternative.[32]

If free markets are inadequate, as I have argued here, and if political bureaucracies are inefficient and corrupt, as public choice theorists tell us, are there grounds for hope that we may still manage to avoid destroying and depleting the natural and biological resources of the earth? Can we feed ourselves without taking bread from the mouths of our descendants? The outlook may not be quite as grim as this dilemma suggests, for people are sometimes moved by concerns that go beyond the narrow interests of *homo economicus*. Some efforts at preservation and conservation have been successful, and there is reason to hope and to strive to extend and reinforce these successes. It is possible that many defenders of the mar-

ket not only overestimate the benefits of markets, but similarly overestimate the probability that political solutions will fail. It is unlikely, after all, that politicians are *all* simply rational vote-maximizers, as they are typically represented in public choice theory. People are moved, at least sometimes, to do what they understand to be right, even when it is not politically advantageous or economically self-interested. Perhaps the degree to which we believe that the behavior of our political representatives diverges from the image of the political process represented by public choice economics is a measure of our hope that we may leave our distant descendants adequate means to provide for their needs.

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NOTES

1. In fact, this paper is part of a larger project which addresses the larger question. See also Wolf (1995, 1996).
2. A more conservative statement of this aim might add the qualification, "...at least if we can avoid their deprivation without undue cost." In Wolf (1995) I defend a stronger account of our obligations to the members of future generations. For a defense of a similar, though somewhat stronger principle, see Barry (1989) and Page (1983). Partha Dasgupta (1974) claims, in a somewhat similar vein, that we should clearly disprefer, from the moral point of view, consumption streams that tend toward zero consumption in the distant future. There is also considerable similarity between the minimal conception of intergenerational justice outlined here and the definition of 'sustainable development' articulated in Bruntland (1987): "Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs."
3. See Hotelling (1931), and Blanshard and Fischer (1990), chapters 2 and 3.
4. See Anderson and Leal, (1991). But see also Menell (1992) and Daly (1992).
5. Both of these tacks have been taken: Jan Narveson (1993) is among those who argue that markets will provide adequately for the future, while Hillel Steiner (1983) is among those who argue that future generations have no valid claims on us, so that it doesn't matter from the moral point of view whether our choices leave them with adequate resources, or leave them miserable and destitute. An alternate strategy for defenders of the market would be to argue that markets, in spite of their faults, are still better than public administration of resources. See Taylor (1992).
6. Explanations of indifference curve analyses can be found in any introductory text on microeconomics. Hal R. Varian (1990) is among the best.
7. "Perfect competition" requires many buyers and sellers, so the market represented here does not reflect perfectly the standard model of perfect competition. However, the features of the model on which I will focus can be generalized to many-participant markets as well. For a more complete account of market efficiency, see Bator (1957) and Arrow and Debreu (1954).
8. Assume that in Eden, productivity is an increasing function of labor.
9. Gauthier (1990) p. 349.
10. Those (such as Pigou and Marshall) who plausibly believe that we are more likely to promote well-being by distributing bread to the hungry than by distributing theater tickets to the bored will reject the common claim that interpersonal comparisons are meaningless. See Cooter and Rappoport (1984). For broader discussions of impersonal comparisons, see Elster and Roemer (1991), Martha Nussbaum (1992), and Sen (1992).

11. Here 'sustainability' is understood as non-decreasing productive capacity. See also Dasgupta (1974), Bruntland (1987), and Pezzy (1992).
12. Ramsey (1928) assumes infinite-horizon maximizers. This is roughly equivalent to an assumption that the participants in the economy are immortal.
13. Dasgupta (1974) and Mishan (1981) use a concept of 'intertemporal pareto optimality'. Unlike the standard time-slice interpretation of the pareto criterion, the intertemporal version takes into account costs and benefits to future persons as well as present persons. However, the standard market theorems do *not* show that markets will achieve intertemporal pareto optima. This is because markets treat questions about future well-being and intergenerational justice as questions about the extent to which present people care about future eventualities. See Broome (1994a, 1994b).
14. Hotelling (1931).
15. While Hotelling's model concerns exhaustible resources, unlike the renewable resources that constituted Eve and Adam's endowment in the example above, the Hotelling model can be extended to renewable resources when such resources can be exhausted by unsustainable use.
16. Page (1977), p. 164.
17. Page (1977) provides a good account of this.
18. Hotelling (1931) p. 152.
19. Hotelling (1931) p. 173.
20. This characterization of the view is from E.J. Mishan (1981) p. 498. Mishan provides an important alternate critique of Hotelling's analysis.
21. This argument leads us to conclude that the Hotelling-efficient time path is not necessarily a desirable intertemporal distribution, since it fails to accommodate common sense ideas about social welfare. E.J. Mishan (1981), pp. 477-513, also argues that Hotelling's conception of an intertemporal optimum fails to meet minimal normative standards.
22. Once again, Mishan (1981) offers additional reasons for believing that this will be so. Mishan argues that markets could approach Hotelling optimal intertemporal distributions only if monopolists were omniscient and perfectly discriminating.
23. This claim is not obvious and requires a supporting argument: Let π = the market rate of interest, v' = the rate at which the value (price) of the resource increases as scarcity sets in, and q = the quantity of resource left unexploited. According to Hotelling, it is rational to extract and sell only to the point at which $v' = \pi$. If $v' \rightarrow \infty$ as $q \rightarrow 0$, then it will never be rational to extract and sell the whole stock, since π is never infinite. Hotelling recognized this. He did not recognize that for most resources it is simply implausible to believe that $v' \rightarrow \infty$ as $q \rightarrow 0$. If this were true, then the last infinitesimal scrap of resource available would have virtually infinite value. For most resources, this is radically implausible, and it is unlikely even for absolutely necessary resources like air, food, and water. For other resources, there must be some least finite value f', such that v' never exceeds f' as $q \rightarrow 0$. There is no need to assume that $v' \rightarrow f'$ as $q \rightarrow 0$, though of course it might. Extraction and sale of the entire resource stock is therefore rational whenever $\pi \geq f'$. The point is that Hotelling's model fails accurately to reflect the way in which the motive to extract and sell depends on the interest rate.
24. Hotelling (1931) p. 140.
25. See for example Beckerman (1974a, 1974b), Simon (1981, 1986), Nickerson (1992), and Narveson (1993). Simon and Kahn (1984) contains numerous Optimistic essays. Many accept the Optimistic View implicitly, and without much argument at all. Nozick's (1984) confidence that "the free operation of a market system will not actually run afoul of the Lockean proviso" (p. 182) is a good example.
26. Darmstadter et al. (1983) p. 89.
27. Simon (1981) p. 47.
28. Daly (1991), p. 263.
29. For example, whenever those in need are destitute.
30. Narveson (1993) claims that human creativity is virtually limitless as does Julian Simon (1981). It is difficult to know what such claims might mean, or what might constitute evidence for their truth. In this context, if "infinite human creativity" is to serve the theoretical function these theorists need, it must constitute a claim that human beings are creative enough to devise

technological solutions to any problems that may arise as a result of environmental destruction, provided only that economic incentives are powerful enough to motivate them to search for a creative solution. The existence of miserable, destitute populations in many environmentally stressed parts of the world should certainly undermine our confidence in this strong version.

31. For example, the model developed in Blanchard and Fischer (1990).
32. There are important exceptions to this empirical claim. David Schmidtz (1994) cites some of the most striking of these. See also Taylor (1991).

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