Preferences in the Future

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Because environmental problems are long run problems with long run solutions, environmental economics has been much occupied with "the discount rate," which is the value of future costs and benefits relative to present costs or benefits. But at least as important is the question of *what* should be discounted, that is, what the value of those future environmental benefits is to future generations. This paper analyzes the role for future preferences and discusses the state of knowledge.

Our focus on future preferences comes for two reasons. The first is that the discount rate part of the benefit-cost debate has largely been resolved.[1] Portney and Weyant, summarizing a 1998 workshop on discounting, write that:

> [V]irtually everyone agreed on a standard procedure for the evaluation of projects with timeframes of forty years or less. Specifically, they agreed not only that it is appropriate to discount benefits and costs for the purposes of making present value comparisons, but also that the discount rate to use should be one that reflects the opportunity cost of capital. (p. 7)

The argument for a market-based rate rests on benefit-cost analysis being a *money-metric* exercise, at least in most circumstances.[2] Benefits are measured in money terms, whenever they accrue. Since the money-metric exchange rate between the present and future is a well-defined concept, there is little question that the appropriate discount rate, once benefits and costs are calculated, is the market rate that would apply to a money transaction with similar risks and time span. This is the basis for the Portney and Weyant conclusion. In a recent report, NOAA also reached this conclusion.

The second and more compelling motivation for this paper is that economists

[1] According to Portney and Weyant, such a resolution does not exist for very-long-run projects such as global warming. We discuss this issue in Section 5.

know considerably more about valuation as a result of the last fifteen years of contingent valuation research and its the surrounding debate. Contingent valuation (CV), or more generally "stated preferences," refers to the use of surveys and referenda to determine preferences for environmental amenities and other public goods. Environmental economics has been transformed by the valuation debate. Efforts to define and measure the value of environmental improvements have forced economists to think deeply about the environment's role in human welfare in general and the utility function in particular.

Because so many of the benefits of environmental improvements lie in the future, it is timely to assess what this large body of valuation research tells us about future preferences.[3]

In almost every case in which analysts have addressed the future-values problem, they have assumed that future citizens will have the same preferences as the present. If this is the case, then two factors are likely to determine the evolution of willingness to pay (WTP): income growth and changes in environmental quality. If future households are richer than the present, then future WTP will be higher than present WTP, assuming the amenity is a normal good. Likewise, a deterioration in environmental quality will likely make future environmental improvements more valuable, assuming the amenity shows diminishing marginal value.

The relationships between income and WTP and between environmental quality and WTP are then the key components for future willingness to pay. These relationships can, in principle, be observed in the cross-section. Existing valuation studies can

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[2]In an important recent paper, Brekke reminded economists that policy evaluation need not be money-metric. The discounting question has not yet been explored in non-money-metric situations.
[3]To be precise, we are interested in future WTP, not just future utility functions. Changes in the utility function are just one reason WTP might change. The next section sets out our arguments more precisely.

therefore be tapped to predict future willingness to pay.

The greater contribution of the valuation literature, however, has been to deepen our understanding of *what* citizens value and how they express those values. We discuss two especially prominent features: *existence value* and *reference dependence*. These are two very different constructs. Existence value is difficult to pin down but appears consistent with a neoclassical view of preferences (namely, transitivity). Reference dependence is a behavioral anomaly, an example of survey behavior that appears inconsistent with the neoclassical paradigm. The evidence for both features is strong.

Despite their apparent incompatibility, we argue that there is a vital connection between these two constructs (existence value and reference dependence) and that this link yields important implications for future WTP. This link is explained in Section 3.

In Section 1 we examine current and future WTP and the discount rate using a simple model. We then look at the role of income growth and changes in environmental quality. Section 3 describes existence value and reference dependence and the connection between them, which we argue is especially important for future preferences. Section 4 presents a two-period model with reference dependence. This is followed by a review of related literature and concluding comments.

Not all environmental problems are part of the valuation debate as we frame it. We want to be clear about the kinds of problems that our argument applies to. Perhaps the cleanest distinction is between problems where the environmental good affects individuals directly (that is, it enters the direct utility function) and those where it affects (only) the budget constraint or production possibilities curve.[4] This paper applies only to

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[4]This is, essentially, the distinction between environmental economics and resource economics. It is not clear-cut. For one thing, it is often unclear what items appear in the utility function: for example, do people

the former type of problems because it is these problems for which assessing individual WTP is essential and, almost always, difficult and tentative. Thus, our arguments apply to endangered species and habitat preservation but not resource extraction. In other words, we do not focus on problems primarily affecting human material well-being; these do not pose an exercise in understanding preferences so much as an exercise in predicting environmental degradation's effects on future incomes or relative prices.

1. Discount Rates and Future WTP

1.1 What Should We Discount?

We can show the key ideas in a simple model with two periods, certainty, and time-separable preferences. Suppose instantaneous utility is $u_t(c_t,q_t)$ where c_t is consumption at t and q_t is some public good, such as environmental quality. Let y_t be the income received in period t. Let ρ be the marginal rate of time preference and let *i* be the market interest rate. For any given $\{y_0,y_1;q_0,q_1\}$, the individual solves:

$$V(y,q) = \max_{c_0,c_2} u_0(c_0,q_0) + \rho u_1(c_1,q_1) \quad subject \ \ to \ \ c_1 = (y_0 - c_0)(1+i) + y_1 \qquad (1)$$

This model can be used to find willingness to pay, in either period 0 or 1, for a change in environmental quality, either current quality, q_0, or future quality, q_1. Willingness to pay in period i for an improvement at time j will be denoted WTP_{ij}.

Willingness-to-pay in period 0 for a future environmental improvement (*i.e.*, at time 1) of Δ, denoted WTP_{01}, is given implicitly by:

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care separately about the existence of a species or just about the commercially valuable contributions that might be made by that species' genes, thus yielding no special entry for "species" in the utility function? Note that environmental goods and amenities will always enter an economy's production set in some way,

$$V(y_0 - WTP_{01}, y_1, q_0, q_1 + \Delta) = V(y_0, y_1, q_0, q_1)$$

Willingness-to-pay in period 1 for that same improvement, denoted WTP_{11}, is given by:

$$V(y_0, y_1 - WTP_{11}, q_0, q_1 + \Delta) = V(y_0, y_1, q_0, q_1)$$

Thus, present willingness-to-pay is related to future WTP for that same improvement by:

$$WTP_{01} = \frac{WTP_{11}}{(1+i)} \tag{2}$$

This relationship follows directly from a reordering of the intertemporal budget constraint in equation (1) and is independent of assumptions about preferences.

In words, the correct discount rate for willingness to pay is the market rate of return – independent of all other elements of the problem, including the consumer's rate of time preference. This is a general result. It arises because benefits assessment is a money-metric exercise. Therefore, the market interest rate must be applied to future WTP because it is the correct price for comparing present and future expenditures.

More generally, for a multi-period problem in which WTP_{ij} is willingness-to-pay in period i (that is, out of income y_i) for an improvement in period j, willingness to pay in different periods are related by:

$$WTP_{0t} = \frac{WTP_{tt}}{(1+i)^t} \tag{3}$$

This set-up casts the problem clearly as one for which the main task is to assess WTP_{tt}.

When there is uncertainty over future willingness to pay, the appropriate discount

otherwise they would be costless to procure. Thus, our distinction is whether the environmental good enters the utility function in any major way.

rate is the one that corresponds to capital investments with a similar time profile and risks. In many cases, however, environmental issues involve risks that are substantially different from any that are offered in the market.[5] It will not be easy to identify the discount rate for such situations.

1.2 The "Environmental" Discount Rate

Confusion arises when willingness to pay is presumed to evolve according to some formula, say $WTP_{tt} = v_0 e^{\alpha t}$. In a standard model, WTP might grow because society is become richer or the amenity level is falling. Substitution into (3) yields:

$$WTP_{0t} = \frac{WTP_{00}}{(1+\delta)^t} \quad (4)$$

where $\delta = (1+i-\beta)/\beta$ and $\beta = \ln(\alpha)$. This may be called the "environmental discount rate." Equation (4) shows the relationship between current willingness to pay for current improvements and current willingness to pay for future improvements.

Equation (4) portrays the problem as having two parts: an assessment of current willingness to pay, WTP_{00}, and the choice of an environmental discount rate, δ. This is the approach taken by Weitzman (1994). However, treating the problem this way – by deriving an environmental discount rate that is then used like a market discount rate – obscures the fundamental issues. There are now at least two constructs that might be called the discount rate, δ and i. They are connected based on another set of assumptions, here parameterized by α. While economists usually understand the difference between δ and i (as Weitzman, 1994, clearly does), the vocabulary can be confusing. Economists

[5]This is why Weitzman (1998, 1999) argues for very low discount rates for long-run projects but accepts

will be better served by focusing on α directly. We adopt this approach in Section 2.

1.3 Altruism

In real world decisions, the current generation makes decisions that affect future generations, a scenario that is more complicated and less constrained than with the single long-lived individual in (1). In assessing the possible benefits of its decisions, the current generation is *not* bound by the future generation's preferences but only by the current generation's generosity and willingness to consider the welfare of future individuals. That is, the current generation is sovereign and this sovereignty breaks the link between WTP_{0t} and WTP_{tt}. Instead, current generations need only assess WTP_{0t}.

What role then for future willingness-to-pay? One simple answer is that future WTP (i.e., WTP_{tt}) is "input" into WTP_{0t}, because the current generation will want to take into account the value of a proposed policy to the future generations that will experience it. How much the current generation might be willing to pay for future environmental improvements would then depend both on (i) how much future generations will benefit and (ii) how important the welfare of future generations is to the current generation. The latter element, the importance of the welfare of future generations, in turn is based on considerations of fairness, justice, and morality across generations, *i.e.*, altruism. The former element is "future WTP."

The precise relationship between future and current willingness to pay depends on the nature of the altruism. There are two kinds, paternalistic and nonpaternalistic. Nonpaternalistic altruism means that the current generation cares about the future generation's overall utility but not about what leads that utility to be high or low.

market rates for most other projects.

Paternalistic altruism means the current generation cares about specific future goods and services.[6] The analogy for the static case is between caring about poor people's consumption of food and shelter (paternalistic altruism) and caring about poor people's welfare without concern about what that welfare derives from (nonpaternalistic altruism). Paternalistic altruists want to subsidize rent, nonpaternalistic altruists want to provide an income supplement. Nonpaternalistic altruism is the common assumption in economics (Brennan; Dasgupta, Mäler, and Barrett; Howarth).[7]

Nonpaternalistic Altruism. To see this distinction in the dynamic case, let the utility of generation t from its own state-of-the-world be $u_t(c_t,q_t)$. If generation 0 has non-paternalistic altruism toward generation 1, then its utility for policy evaluation purposes is $u_0(c_0,q_0) + wu_1(c_1,q_1)$, where w is the weight assigned to the welfare of the next generation. Normative arguments would determine the size of w. A higher w indicates greater weight placed on future utility. Its role is similar to a higher ρ in model (1).

Some results for discounting analysis have been derived. The main result with nonpaternalistic altruism is that the current generation should use a market discount rate and calculate the present value of WTP_{tt}, as in equation (3). The reason for using WTP_{tt} and a market rate is the same as before. Since the current generation is willing to bequeath capital to the future at a rate of return i and since the future generation is willing to trade consumption for environmental quality according to WTP_{tt}, and since the current generation "respects" the future's preferences when making consumption/environment tradeoffs, then the market discount rate must be applied to WTP_{tt}.

[6]See McConnell for discussion of paternalistic and non-paternalistic altruism in the static case.

[7]However, the latter two papers, which look at climate change, use models in which only consumption enters the utility function. This yields a considerably smaller opportunity for paternalistic altruism. Hyperbolic discounting (Arrow; Cropper and Laibson) introduces paternalistic altruism, but of a limited

The specific role for altruism comes through the market rate, *i*. A nonpaternalistic altruist will prescribe policies that lower the market rate in order to spur investment and increase the resources going to the future. The future generation can then spend these resources as it pleases.

In sum, any desire by the current generation to increase the welfare of future generations or, more precisely, to weight more highly their utility, will come through policies that increase *all* investment. Such policies will lower the market rate of return and raise future utilities. Environmental projects must be judged against this discount rate. The benefits of future environmental improvements are measured by WTP_{tt}.

Paternalistic Altruism. If generation 0 has paternalistic altruism toward generation 1, then its utility for policy evaluation purposes is $u_0(c_0,q_0) + A(c_1,q_1)$, where A is some function that represents how generation 0 cares about c_1 and q_1. $A(c_1,q_1)$ must take some form other than a transformation of $u_1(c_1,q_1)$. Unfortunately, few economists have looked at dynamic models with paternalistic altruism, and the role of WTP_{tt} is unknown.

2. Future WTP in the Standard Model: Changes in Income and Environmental Quality

The model in (1) has two factors that might affect future willingness-to-pay: future income and future environmental quality. Under some simplifying assumptions, it will be possible to link current and future preferences through a fixed formula, as in $WTP_{tt} = v_0e^{\alpha t}$. Such a formula would typically be based on assumptions about income growth and changes in the underlying environmental quality. While it is possible to posit a change in actual preferences, this has rarely been done.

nature, in which present generations respect all future preferences except future time preferences.

In this section we switch to a continuous time model, which makes for easier exposition. Suppose that V(y,q) is separable in time and let instantaneous utility be $v(y_t,q_t)$. There is no time argument on utility, in keeping with the assumption of unchanging preferences. Separability of V in income (as opposed to separability in consumption in model (1)) is not in general valid, but little is lost by this assumption provided we are careful about the behavior of the marginal utility of income over time, $dv_y(y_t,q_t)/dt$.[8] Willingness-to-pay at *t* for a change Δ is denoted WTP_t and is given by:

$$v(y_t - WTP_t, q_t + \Delta) = v(y_t, q_t) \tag{5}$$

In this simpler model, only a single time subscript is needed on WTP.

In this model, willingness to pay is a function of income and environmental quality. Define the income and environmental elasticities of willingness to pay as:

$$\eta = \frac{dWTP}{dy}\frac{y}{WTP} \qquad \lambda = \frac{dWTP}{dq}\frac{q}{WTP}$$

The growth rate of WTP is then given by:

$$\frac{W\dot{T}P}{WTP} = \eta\frac{\dot{y}}{y} + \lambda\frac{\dot{q}}{q} \tag{6}$$

When the right-hand expression in (6) is constant, the solution is $WTP_t = v_0 e^{\alpha t}$.

The size of these elasticity effects can be measured using typical valuation techniques administered to the current generation; no speculation about future generations' preferences is needed. Analysts must still predict income growth and environmental quality changes. We now turn to the evidence on the elasticities.

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[8] In this section we use subscripts for partial derivatives.

2.1 WTP and Income

Valuation studies often examine income and willingness to pay, although only a few papers have attempted to summarize the findings. Kriström and Riera briefly review the cross-section literature for a variety of environmental goods and suggest that most income elasticities of WTP are in the range 0.2–0.3 and that elasticities greater than one are almost never observed. Horowitz and McConnell (2000) review the WTA/WTP literature, which includes both private and public goods, and find income elasticity estimates ranging from 0.12 to 0.55. McFadden estimates $\eta = 0.32$ using a number of different CV treatments for wilderness valuation. Flores and Carson discuss the derivation of η, which they label η^{WTP}, but do not present empirical evidence. Note that income elasticities of WTP are not required to sum to one across goods.

Time-series evidence about η is indirect and imprecise. There is some general time-series evidence that η is positive, based on the observation that environmental concern in the U.S. has increased as incomes have risen over time. This evidence is not as concrete as for the cross-section.

2.2 WTP and Environmental Quality

The second component of WTP growth depends on the relationship between WTP and "baseline" environmental quality, q. Studies that have looked at this relationship have been rare. The evidence, such as it is, has focused on whether the derivative dWTP/dq is non-zero rather than on precise measurement of its size..

A typical assumption is $dWTP/dq < 0$, which implies that the higher is the initial environmental quality, the lower the value of environmental improvement. This assumption is common because, for example, if the good in question were available at a fixed price, then strictly downward-sloping demand for q implies dWTP/dq $<$ 0 when there is no income effect. This behavior, also known as diminishing marginal value, is a prominent part of economic intuition, although it is not required for transitivity. A zero derivative, dWTP/dq = 0, is the same as reference dependence, a result that we explain further below. Reference dependence thus implies $\lambda = 0$.

Evidence for diminishing marginal value with private goods was found by Horowitz and McConnell (1999) who found that individuals' compensation demanded to give up one coffee mug decreased by 12 percent as the endowment of mugs rose from one mug to three and by 18 percent as the endowment rose from three to four.

A small number of studies have looked at what is called the baseline effect for health risks: Is willingness-to-pay to reduce a mortality risk from some source higher for sources with higher baseline riskiness? The evidence is mixed, but most have found that the answer is yes (Horowitz and Carson).

There have been very few studies of diminishing marginal value for public goods. Rollins and Lyke analyzed WTP responses for up to 39 new national parks. They estimated $d^2WTP/d\Delta^2$ and then constructed an estimate of dWTP/dq based on the relation $\frac{d^2WTP}{dqd\Delta} = \frac{d^2WTP}{d\Delta^2}$. They found that WTP for one additional park decreased by 47 percent as the number of (hypothetically) existing parks rose from 29 to 30.

Further research on the effect of environmental quality on WTP would be valuable, both as a way of estimating λ and as an innovative test of reference dependence.

2.3 Estimates of WTP Growth

We can use these results to construct estimates of WTP growth. Suppose that real incomes are growing at three percent per year. Then an income elasticity of 0.4 means that WTP will grow by at least 1.2 percent per year, provided $\lambda < 0$ and $\dot{q}/q < 0$.

There are few explicit claims about $\dot{WTP}/WTP$ in the literature. Hagen, Vincent, and Welle determine the present value of the benefits of spotted owl preservation under different assumptions about income growth. They first assume that willingness-to-pay remains constant as a percentage of income and then calculate benefits assuming that income (and therefore WTP) grows at 3 percent. They also calculate what happens when WTP grows at 0 percent (and thus falls as a percentage of income), although they label this an unlikely scenario. Hagen, Vincent, and Welle is one of the clearest pieces of research in showing assumptions about future WTP being made separately from the discount rate.

3. Further Contributions of *Valuation*

The valuation literature has, however, a potentially much greater contribution for future willingness-to-pay. It is based on a confluence of two of the major contributions of the valuation literature: existence value and reference dependence. With reference dependence we no longer assume that future citizens have the same preferences as the present, at least not in the specific sense of the previous sections.

Existence value, also known as passive or nonuse value, captures the value that individuals place on the natural world as a source of meaning, inspiration, or obligation; a concern that is independent of nature's role in providing consumer goods and that is not proportional to visits to scenic areas or other physical experience of the environment. Existence value is often cited as the main reason why people want to conserve wilderness areas or endangered species – areas they may not visit and species they may not see (*e.g.*, Metrick and Weitzman). One contribution of valuation research is a greater understanding of existence value and an appreciation of just how large a component of environmental values it can be. Much remains unknown about the exact nature of existence value, of course, but its substantial role in environmental attitudes seems now established.

3.1 Reference Dependence

Reference dependence (RD) is a behavioral property introduced to economists by Tversky and Kahneman.[9] Under their model, economic decision-making was based on a value function that was defined on *changes* from a reference point, not on final outcomes. The reference point is typically construed to be the "current situation." The reference point may change over time. This is why reference dependence may play a role in determining future willingness-to-pay.

Suppose the value function can be written $\upsilon(y;r,\Delta)$ where r is the reference point and Δ the proposed change in the environmental good; we now use a semicolon to separate income and the environmental good. The final level of the good is $r+\Delta$. Under the neoclassical model, the value (or utility) function is defined over final consumption, thus we write, with some abuse of notation, $\upsilon(y;r+\Delta)$. In words, utility derives from the ultimate consumption bundle. Under the reference dependent model, the value function is $\upsilon(y;\Delta)$, at least in the strictest version; in this specification, subjects value goods *only*

[9] Bowman, Minehart, and Rabin claim that reference dependence in risky choice goes back to Markowitz.

as changes from the reference point. Under this version, willingness-to-pay is independent of r, dWTP/dr = 0. Under the weaker version, which has the form $\upsilon(y;r,\Delta)$, WTP is not independent of r; however, the cross-partial relationship will fail. That is,

$$\frac{d^2WTP}{dqd\Delta} \neq \frac{d^2WTP}{d\Delta^2}.$$

Reference dependence is central to much of the work on psychology's implications for economics, as Rabin demonstrates. For example, two more prominent aspects of Tversky and Kahneman's behavioral model - (i) loss aversion, which implies willingness-to-accept greater than willingness-to-pay, and (ii) diminishing sensitivity, which implies risk aversion in the domain of gains and risk-seeking in the domain of losses - are not well defined if RD is not satisfied, because without a reference point, outcomes cannot be classified as losses or gains.[10] A role for a reference point is also part of other non-neoclassical models, such as status quo bias (Samuelson and Zeckhauser) and status quo aversion (Patt and Zeckhauser).

Many behavioral anomalies and valuation patterns beyond reference dependence have been identified or proposed. We focus on RD because there is substantial evidence for it and because it has straightforward, important implications for choice. In environmental contexts, reference dependence is further noteworthy because of its connection with existence value. We turn to this now.

3.2 Does Existence Value Give Rise to Reference Dependence?

[10]This condition has sometimes gone unrecognized. Because loss aversion requires reference dependence, evidence for loss aversion must be treated as evidence for RD. However, neoclassical utility can yield behavior that is similar to loss aversion, as when $\upsilon(y;r+\Delta)-\upsilon(y;r) < \upsilon(y;r)-\upsilon(y;r-\Delta)$. In this case, the

To see why existence value and reference dependence play an intertwining role, it helps to go far afield and consider how we, the present generation, have been affected by the extinction of the passenger pigeon in 1914. The passenger pigeon is arbitrary but useful because extinction is discrete.

No doubt we would fight hard to keep this species from becoming extinct were its extinction to be occurring presently. But now, not ever having known or seen a world with passenger pigeons, we are not appreciably affected. It is unlikely, for example, that other species similar to the passenger pigeon are more precious to us than they would be if the passenger pigeon were still around, or that the habitat that supported the pigeon is less valuable after the pigeon's extinction. The pigeon is missed, but its disappearance likely does not affect a single other instance of WTP for any environmental good.

The natural world that we, the public, value is the natural world that exists now and that will, presumably, exist into the future if we are careful, not the natural world that "was." In other words, we have reset our clocks to Nature as it exists for us in the present and go on from there. This is the very essence of reference dependence. Thus, we, the authors, posit that existence value *engenders* a kind of reference dependence.

This argument rests on the pigeon's existence value because if its extinction were also to have affected people's incomes or wealth, then its consequences would continue to be felt. The extinction of a resource that has a substantial use-value component would affect the value of other resources and amenities whenever WTP for those amenities is increasing in income. The fact that citizens might care deeply about something whose subsequent loss does *not* affect our material well-being is a shared feature of both

individual evaluates final outcomes, but "gains" appear less valuable than "losses." Thus, some of the apparent evidence for loss aversion may not be evidence for RD.

reference dependence and existence value.

Existence value is not the only example of reference dependence, although it may be the most compelling. A kind of reference dependence in outdoor recreation, for example, in which the disappearance of fishing streams causes people to stop taking up fishing and therefore not to care about lost fishing opportunities, seems more properly an expression of habit-formation than true reference dependence. Still, we do not claim that reference dependence is exclusively a feature of non-use values; it could also be exhibited with use values.

The degree to which existence value is or is not subject to reference dependence is harder to establish. The environmental attributes most likely to be the subject of existence value (*e.g.*, endangered species or wilderness areas) will rarely vary in the cross-section; indeed, it may be that possessing a cross-sectional component makes an attribute not a candidate for true "existence value." Therefore, analysts must look at time-series changes in the environment in order to test RD. Such tests will be difficult, since information about environmental problems also varies over time.

Loewenstein and Frederick argue that disutility from possible extinction of the desert pupfish comes from the losing of the pupfish (which is transitory), not from the presence or absence of pupfish in the world. If people "overweight" this brief period of disutility relative to the much longer period in which the pupfish is extinct, they may fight to preserve the species even if they seem to care little about it after it is gone. This is essentially the same as our argument, although less extreme.[11] One can only care about losing something that one has; in other words, existence value is subject to reference

[11]We have combined two of their arguments. For the pupfish, they argue that individuals may feel responsibility for extinction rather than having existence values.

dependence.

There are some counterexamples. The desirability of removing Hetch Hetchy dam and restoring the wild canyon suggests that some values do not evaporate when the environmental amenity no longer "exists." (On the other hand, plans to remove Hetch Hetchy have not been carried through.)

The reference dependence related to existence value may not be of the strict form. Today's citizens might like to return the environment to how it was five hundred years ago. The point is that they do not care about this as much as people five hundred years ago would have.

4. A Reference Dependent Model

Suppose that a policy-maker decides not to adopt an environmental policy now. She might want to wait, for example, to see whether environmental quality deteriorates, and if it does, adopt the policy then. She is more willing to adopt it under deterioration because a policy to improve the environment will be more valuable when quality is low. Suppose that when the next period arrives, the environment has indeed deteriorated. Under RD, she becomes accustomed to the new environmental quality and does nothing – she is back in the position she was originally. Our main result is that, under reference dependence, future decision-makers will "accept" low environmental quality that present decision-makers would want to avoid.

4.1 Model

To illustrate this situation, we construct a two period model with reference dependence. RD preferences lead us to ask different questions from Sections 1 and 2. We turn to these next.

Let utility be $\upsilon(y,\Delta_r) = yQ(\Delta_r)$ where Δ_r is the change in environmental quality from reference point r. Let $Q(\Delta_r) = \alpha(3+\Delta_r) - \beta(3+\Delta_r)^2$. Utility is increasing in environmental quality for $3+\Delta_r < \alpha/2\beta$, a condition that holds for all examples below. Utility is furthermore linear in income and concave in environmental quality. It has a positive cross partial derivative, $\upsilon_{\Delta y} > 0$, which implies that an increase in income raises the marginal utility of environmental quality, a common assumption.

In period one, environmental quality is q_H. In period two, quality deteriorates to q_L with probability p or stays the same with probability 1-p.[12] A policy to counteract this deterioration is available at a cost of 5% of income. The policy may be adopted in either period. If it is adopted (in either period) then in period two environmental quality deteriorates only to $q_L+\delta < q_H$ with probability p or stays at q_H. with probability 1-p. In other words, if the bad state of the world does not occur, the policy has no effect. Note that because the same quality improvement is achieved even if the policy is adopted in period two, there is no penalty for waiting to adopt. This assumption can be easily changed. Let $\alpha = 32$, $\beta = 4$, and $\delta = 0.5$. Let $q_H = 3$, $q_L = 2$, and $y = 100$.

If the reference point is q_H then the policy is desirable in the bad state of period two. This is shown in (7). In the bad state, the policy yields $q_L+\delta$. Therefore, the policy-induced change is $\Delta_H = q_L+\delta-q_H$. Without the policy, environmental quality in the bad state is q_L and the quality change is q_L-q_H. In (7), utility from adoption under $r = q_H$ is on the left and utility from non-adoption on the right:

$$\upsilon(y\text{-}c,\ q_L+\delta-q_H) = 5225 > 4800 = \upsilon(y,\ q_L-q_H) \tag{7}$$

This inequality implies that from the standpoint of the current reference (q_H), the decision maker *thinks* she will want to adopt the policy in period two if quality falls to q_L.

If the reference point is q_L then the policy is not desirable even in the bad state. This is shown in (8). In the bad state, the policy again yields $q_L+\delta$. Therefore the change induced by the policy is $\Delta_L = q_L+\delta-q_L$. Without the policy, the quality change is $q_L-q_L = 0$. In (8), utility from adoption under $r=q_L$ is on the left and non-adoption on the right:

$$\upsilon(y\text{-}c,\ \delta) = 5985 < 6000 = \upsilon(y,\ 0) \tag{8}$$

This implies that when period two arrives, if q_L occurs and the reference point becomes q_L, the decision-maker does not want to adopt the policy even though quality has fallen.

We next look at the first period decision. Utility is current utility plus expected future utility; for simplicity, there is no time preference. The reference point for future utility is the current quality, q_H. If we adopt the policy now, current utility is $v(y\text{-}c,0)$ and future utility is $v(y,\Delta_H)$ with probability p and $v(y,0)$ with probability 1-p. Utility from acting now is thus:

Adopt now: $$\upsilon(y\text{-}c,0) + p\upsilon(y,\ q_L+\delta-q_H) + (1-p)\upsilon(y,0) = 11{,}450 \tag{9}$$

Utility from waiting depends on what the individual believes she will do in period two. If she does not recognize that the reference point will change, then she anticipates undertaking the policy in period two with probability p, as shown by (7). Utility from waiting in this circumstance is:

[12]Uncertainty in future quality is not necessary. We could accomplish the same objectives if there were two

Wait: $$\upsilon(y,0) + p\upsilon(y\text{-}c,\ q_L+\delta\text{-}q_H) + (1\text{-}p)\upsilon(y,0) = 11{,}612.5 \qquad (10)$$

Compare (9) and (10). If the individual does not recognize that the reference point will change, then she does not adopt the policy in period one. But, when she gets to period two, she does not adopt either, as shown by equation (8).

It is useful to consider what would happen if the individual recognizes the change in reference point and realizes now that she will not adopt in period two. We change (10) to reflect this recognition. The utility from not adopting is:

Do not adopt: $$\upsilon(y,0) + p\upsilon(y,\ q_L\text{-}q_H) + (1\text{-}p)\upsilon(y,0) = 11{,}400 \qquad (11)$$

Compare (9) and (11). If the individual knows she will not enact the policy in period 2, she prefers to enact it now. (Reference dependence would be irrelevant if (11) were higher than (9), since then even if the individual recognized her RD she would adopt in neither period.)

4.2 Discussion

Under reference dependence, future decision-makers may "accept" low environmental quality that present decision-makers would want to avoid. To compensate, present decision-makers might either postpone (and then do nothing) or act early, depending on whether they foresaw the effects of RD. But either way, they do not do what they truly would like, which is to wait to see what happens and to act if environmental quality deteriorates.

There are several points worth noting. First, this model does not exhibit dimi-

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decisions to be made or if a better technology were available in the second period (thus giving the nishing sensitivity to losses and exhibits only a "necessary" form of loss aversion, namely that implied by concave utility (diminishing sensitivity to gains); in other words, there is no kink at $\Delta=0$. Thus, our results are due to reference dependence and not to other behavioral features. Because of this restriction, our results are consequently mild. Stronger results almost surely require much stronger assumptions. For example, in a model of consumption and savings, Bowman, Minehart and Rabin impose several additional assumptions, including risk-loving preferences in losses, in order to show the (still mild) result that first period consumption is sometimes above the reference point.

Second, the outcome depends on whether the individual predicts that her reference point will change. Loewenstein and Frederick review evidence and conclude that individuals are relatively good, but not perfect, at predicting how they will feel about social and environmental changes. Loewenstein, O'Donoghue, and Rabin present a model of an individual's ability to predict changes in his reference point; bias in reference point prediction is called projection bias.

Third, the ability to predict changes in the reference point or their effect on future decisions is conceptually separate from how the reference point evolves and how it affects choice. In the latter regard, we have assumed an extreme form of RD in which only changes in q enter utility. A more general form in which both r and Δ_r enter utility is analyzed in Loewenstein, O'Donoghue, and Rabin.

Fourth, we assume no reference dependence in income. As long as RD is weaker for income, our results hold. This is similar to assumptions made about loss aversion. For loss aversion to explain the WTA/WTP disparity, loss aversion for the good must be stronger than loss aversion for money. Our model takes a similar tack.

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individual a reason to wait before acting.)

Fifth, we assume that current environmental quality is used to evaluate future outcomes in both a descriptive and prescriptive sense. It is the basis for our claim that what the current decision maker truly wants is to wait to see what happens to the environment and act if quality deteriorates, and that he will act now if he recognizes the reference dependence effect. This is closely related to our third point about what the appropriate reference point is, although there we intended only a descriptive interpretation.

4.3 The Reference-Dependence Effect on WTP

In this section we look at how reference dependence affects willingness-to-pay. Consider first the neoclassical model. Willingness-to-pay for Δ, denoted WTP^{NC}, is given by $v(y-WTP_H^{NC}, q_H+\Delta) = v(y, q_H)$ when initial quality is q_H and $v(y-WTP_L^{NC}, q_L+\Delta) = v(y, q_L)$ when initial quality is q_L.

Under the RD model, willingness to pay for this Δ, denoted WTP^{RD}, is given by $\upsilon(y,0)=\upsilon(y-WTP_H^{RD},\Delta)$. Note that WTP in this example is independent of initial quality, thus $WTP_L^{RD}=WTP_H^{RD}$.

To make the models commensurate they must be calibrated such that $WTP_H^{RD} = WTP_H^{NC}$. This is desirable because in the current period q_H *is* the reference point, so that even a neoclassical individual might be modeled as looking at changes in q relative to a "reference point."

The effect of RD is measured by $WTP_L^{NC} - WTP_L^{RD}$. Our main result is:

$$WTP_L^{NC} - WTP_L^{RD} = WTP_L^{NC} - WTP_H^{NC} \tag{12}$$

The right side is the effect of the endowment on marginal value, a true endowment effect.

The previous section suggested that RD might reduce WTP when quality is declining. Equation (12) shows that the decrease in willingness to pay due to reference dependence is exactly equal to the neoclassical endowment effect. That is, it is exactly equal to the amount by which the change in q would affect WTP in a non-RD world. Note that reference dependence is more costly if WTP is highly sensitive to underlying environmental quality.

(To get equation (12), write $WTP_H^{RD} - WTP_L^{RD} = 0 = WTP_L^{NC} - WTP_L^{NC}$. Substitute WTP_H^{NC} for WTP_H^{RD} and transform to get (12).)

5. Other Relevant Literature

The crucial role of speculation about the future has not gone unremarked. Schelling, in his influential article on global warming, asked the reader to imagine how people in 1900 would have speculated about the world in 2000 and how global warming would affect it. It is unlikely they would have anticipated the particular conveniences we enjoy nor imagined how the warming's effects might in turn be mitigated by those conveniences. Bradford expresses similar skepticism about our ability to predict what life will be like in the future. Our paper follows Schelling's lead but focuses on future attitudes toward nature rather than on future technologies.

Loewenstein and Frederick also discuss predicting future preferences. They look in depth at our ability to predict reactions to environmental change and argue that there is a slight tendency for people to underestimate the degree to which they adapt to change.

Portney and Weyant suggest that economists are uneasy about using a market rate for very-long-run environmental problems such as global warming. They are uneasy because they believe that global warming should at least be worth arguing over, but under the market rate approach, future benefits appear minuscule, so why bother? Long term policies seem not even worth discussing; we know they will fail. The contributors to their volume suggest a number of alternative approaches, but none examines the most straightforward source of unease, that economists have under-estimated future benefits. We have argued that further examination of future preferences is indeed warranted.

Kopp and Portney suggest that it will be nearly impossible to gauge future preferences because the number of items whose values must be estimated is huge and uncertainty about those values is overwhelming: "What value should we attach to lives prolonged [one hundred years from now]?" (p. 89). They recommend a mock referendum: Would the individual vote for a project with a particular time profile of costs and consequences? This remedy leaves it to the individual to draw conclusions about the issues we have raised here, an area that research should elucidate rather than abandon. We also wonder how future consequences can be predicted without making assumptions about what future generations will do.

6. Concluding Remarks

We have tried to zero in on the external factors and behavioral precepts that will most affect future preferences, future choices and, through these, the fate of current policy decisions. We also hope we have substantially clarified the discount rate debate.

There are yet other features that may affect current and future preferences that deserve research. Preferences for the environment are almost surely not time-separable: Is it likely that individuals would pay anything at all to preserve rainforest for the next ten year if it were certain that the forest was going to disappear at the end of those ten years? Only time-nonseparability can make the value of one year of rainforest existence depend on how long the rainforest is going to exist. Such an issue needs further empirical and conceptual research. In a similar vein, we know that individuals also get utility from anticipating good outcomes and accelerating bad ones (Loewenstein). Those features also remain under-investigated for global warming and rainforest destruction.

No other branch of economics has thought as long and hard about human values, how they might be revealed, and how they should affect real-world policy decisions. Existence value remains the most prominent of those values, and much remains to be explored and pursued on its behalf.

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