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INTERGENERATIONAL EQUITY AND THE RATE OF DISCOUNT IN LONG-TERM SOCIAL INVESTMENT

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1. INTRODUCTION

The importance of the correct choice of discount rate for social (or indeed individual) investments hardly needs elaboration. In the social context, the discount rate is, at least in part, an expression of concerns about equity between the present and future generations and among future generations. I say, in part, because it also expresses both an expectation of the rates of return available to future generations in alternative uses of capital and an expectation of the growth of income of the representative individual.

The immediate motivation for rethinking the question of intetermporal discount rates is the concern over climate change. In particular, I was one of the lead authors of the chapter on the discount rate in the recent report of the Intergovernmental Panel on Climage Change (Arrow et. al., 1996, referred to below, for brevity, as 'IPCC'), and my discussions with the other lead authors was very clarifying, if only by way of disagreement.

There is an underlying tension in regard to equity considerations for the future. On the one hand, we are accustomed by our everyday economic behavior to discounting future returns; we do not count future benefits as equal to present ones. In other words, we do not treat our own individual futures on a par with

our present. Indeed, since some of our saving is for the benefit of our own heirs, we are in effect discounting their welfare. But when we consider others, a principle of universalizability seems to be inevitable. Why, from an ethical viewpoint, should others not be considered as equal to oneself? With regard to policies with little or no extension in time, cost-benefit analysis is based on the equality of all individuals. Why does this not extend to the future? The fact that an individual will be alive at some future time instead of today does not seem to be a morally relevant distinction. Hence, so it is argued, proper social policies, such as abatement of carbon dioxide emission to reduce the burden of climate change on the future, should be chosen to treat future generations equally with the present. This position implies that the rate of discount or, more precisely, the rate of pure time preference should be zero.

Considerations of this type have certainly underlain the policy constraints on nuclear waste disposal, an issue with a time horizon which dwarfs that of climate change. Statements that the probability of rupture within the next ten thousand years should be very small imply a virtual absence of discounting, since even a modest discount rate would assign virtually no weight to deaths beyond a few hundred years.

In this lecture, I seek to summarize a selection of the vast literature on the social rate of discount and, in particular, the ethical and other arguments for and against the presence of pure time preference. I start with a general discussion of the importance of discounting, and I conclude by presenting a viewpoint

conceptually very different from the usual one, though with antecedents in both economic and philosophical literature. In particular, it revives a point of view originated by Phelps and Pollak (1968). Briefly, I assume that individuals (here, generations) are aware of their ethical obligation to treat all generations equally but do not necessarily feel compelled to sacrifice themselves completely to that obligation. This leads to a game-theoretic interpretation of savings behavior in which, in effect, the entire future is exponentially discounted, even though each generation would like to see all future generations treated equally.

2. INTERGENERATIONAL CHOICE: THE SIGNIFICANCE OF DISCOUNTING

We start from the obvious remark that intergenerational choice is sometimes most usefully expressed by discounting. As everywhere in economics, prices, in this case discount rates, are dual to quantities, in this case savings rates in the most general sense, that is, including all current sacrifices which lead to benefits or avoided damages in the future. If we assume that the investments under consideration are a small part of total, then it is reasonable to use the prices already determined by the system as a measure to be applied to any given new proposed investment. I will not deal here with the special problems of irreversible investments. I think it fairly clear that such a large volume of investment is reversible that this is the relevant assumption at the margin.

In climate change, there are three kinds of possible policies, abatement, mitigation, and adaptation. Our focus here is on abatement, that is, steps which

reduce the emission of carbon dioxide and other greenhouse gases. Since emission equals (outptut) x (energy per unit output) x (emissions per unit energy used), it is clear that reducing emissions requires some or all of the following policies: output reduction, increased efficiency in the use of energy, and choice of fuels to minimize emissions. Recall that the temperature effects of these gases depends on their *concentration*, that is, the stock in the atmosphere. The rate of increase of concentration is equal to the emission less the extent of leaking of the gases from the atmosphere to sinks such as the ocean and vegetation. A reduction in emission will have little immediate impact on concentration. It will take a sustained effort at reduced emission to achieve a reduction in concentration. When one adds that the marginal effects of concentration are increasing, it can be seen that the substantive effects of mitigation today are essentially first realized in a relatively long future, perhaps fifty years.

The other forms of policy relative to climate change, mitigation (taking steps to offset directly the effects of climate change, such as dikes against rise in the water level or air conditioning) and adaptation (changing production methods, particularly in agriculture, to minimze the economic impact) are taken virtually concurrently with the climate change and therefore have much less of an investment aspect.

It is the length of time between cost and benefit which makes the investment aspect of abatement so dramatic. The discount rate applied to a

future benefit is of course sensitive to the interest rate used. But it is important to recall that the sensitivity of the discount to the interest rate increases with the length of time between the cost and the benefit. To illustrate, I exhibit the present value of a benefit fifty years in the future for each of a number of interest rates.

PRESENT VALUE OF ONE DINAR FIFTY YEARS HENCE AT DIFFERENT INTEREST RATES

Interest Rate	Present value
1%	.61
4%	.14
5%	.08
7%	.03
10%	<.01

This range of interest rates was not made up just to illustrate the importance of a correct choice of interest rates. Both extremes are to be found in the literature. The 10% rate was in fact official United States policy for twenty years, as discussed below. Clearly at 10%, no one will take much serious interest in abatement measures unless a catastrophe is predicted. At 1%, on the other hand, it would take only a modest excess of future benefits over present costs to justify present action. Notice that even a change from 4% to 5% causes a considerable difference. This is difficult, because it is certainly unlikely that any reasoning will differentiate between those two rates.

3. IS THE CHOICE OF DISCOUNT RATE ETHICAL OR PRESCRIPTIVE?

In IPCC, a distinction is drawn between 'prescriptionist' and 'descriptionist' bases for choice of the appropriate interest rate for discounting. I will use the terms, 'ethical' and 'descriptive' instead. In the ethical point of view, the evaluation of future flows is an expression of ethical or moral judgment. These express the socially desirable demand for provision for the future. Of course, the amount actually supplied depends, as always, also on the opportunity set and on the presence of complementary or substitute commodities. By these I mean the return on the possible investments and on the degree to which the needs of the future are being met by other means, for example, by provision by intermediate generations and by technological progress.

In the descriptive approach, it is argued that public investment simply displaces private investment and therefore should earn a rate of return equal to market rates of discount or observed returns on investment. Although these are frequently identified, they are clearly not the same thing. In the United States. a rate of return to be earned by public investment was set on the basis of some studies of the real rate of return on corporate investment. In 1972, a study yielded 10% as the appropriate rate; a later study, in 1992, revised this to 7% (see United States Office of Management and the Budget, 1972, 1992). I will argue below that these very high rates are indefensible even on descriptive terms.

A crucial aspect of intertemporal allocation is that the decisions are made by the present generation. They are, of course, made in the light of expectations about the future, both about exogenous events and about allocation to be made by future generations. But they cannot, even in principle, be regarded as the working out of some social contract or, in modern terminology, as the outcome of a cooperative game. In this crucial respect, decisions about saving or abatement have a different setting than the usual contexts of either democratic politics or individual decision-making. The consequences of global warming will be felt by future generations, not the present one.

Abatement and other very long-lived public investments are thus definitely matters of moral obligation, not of self-interest. Schelling (1995) has therefore distinguished sharply between discounting because of futurity and altruism and argued that abatement must be motivated by the latter. This point of view has in fact been argued much earlier in a series of papers in the 1960s (Sen, 1961, 1967; Marglin, 1963, Lind, 1964). Marglin gave a very general formulation in which individuals were concerned for others today and also for their own descendants and others tomorrow. Contrary to Schelling's way of putting it, Sen, Marglin, and Lind still regarded the decision as an optimization but one in which there are interdependencies or externalities. These are precisely the moral obligations to the future and to others.

Even if the ethical view is accepted, it would still be true that to the extent that private investment was displaced, the opportunity cost argument will be

valid. Indeed, it does appear that no matter what our view of the value of future benefits is, it remains true that if the marginal productivity of capital in private use were constant (independent of the amount invested) and if the government could invest in the private sector, then public investment should be evaluated at that rate of interest.

However, in a mixed economy, the government does not invest in the private sector. If public investment is financed by taxes, then it displaces both consumption and private investment. Indeed, since national income is primarily consumption, the income tax falls more on consumption than investment. Other taxes tend to hit consumption even more than the income tax. This led to a literature which was partly descriptive, partly ethical. The rate of discount should be an average of the social rate of time preference, governed by altruism, with the rate of return on private capital. This proposition was first stated by Eckstein (1957); see also Sandmo and Drèze (1971).

As a digression, we note that the appropriate measurement of the rate of return on capital is not well caught by the rate of return to corporations. In a perfect capital market, the rate of return on capital should be equal in all uses. But in fact the rates on organized securities market differ drastically from the rate of return in the corporate sector and from each other. It is no surprise that the key explanation for these differences is the presence of risk, more exactly, of uninsurable risk. If a complete set of contingent securities market existed, firms would have no risk, since it would all be insured. Contingent markets cover only

a small set of business risks, for reasons we understand from the theory of asymmetric information.

Is there any market evidence about the riskless rate of return? It must be recalled that with securities denominated in money, the risks include inflation as well as default and future changes in short-term rates. One possibility is to ask what rate of return could be earned by investing in such a way that there are virtually no risks. The only way of meeting this goal has been to buy short=term treasury bills; this strategy would have yielded an average real return of 1% over the period 1889-1978; see, eg., Kocherlakota (1996, Table 1). Hence, even a complete descriptive (opportunity cost) argument does not necessarily lead to high discount rates.

To return to the main theme, I have, I hope, convinced you that ethically-based discounting is at least relevant to the choice of a rate of discount for climate change or other public goods. But what methodology can we apply to determine the ethical rate of discounting? By definition, market data are not directly available, for ethical judgments are not represented on the market.. But we can resort to introspection in exploring the conceptual ethical indifference surfaces between consumption and savings, including in particular abatement. We can test a rate of discount by observing the savings rate that would be implied in a first-best world. If it is more than would be credible, then we can conclude that the proposed discount rate is too low.

As a basis for subsequent discussion, let me recall briefly the classical utilitarian criterion with discounting of the future:: maximize the sum of discounted utilities of consumption, i.e.,

$$\Sigma\, \delta^t\, U(c_t), \qquad (1)$$

Here, U(c) is the utility (or, better, felicity) of consumption at any moment of time, and δ is the rate at which utility one period ahead is discounted to the present. Clearly, if $\delta = 1$, then no differentiation is made between present and future satisfactions. This injunction can be derived from several consistency conditions for rational choice, primarily separability over time and stationarity (the future looks the same from every point in time). These conditions are as applicable to ethical as to descriptive formulations. A similar and sometimes more convenient formulation can be made when time is treated continuously; the sum is replaced by an integral. In this form, the utilitarian criterion implies the well-known formula,

$$\text{rate of discount} = \rho + \theta g, \qquad (2)$$

where ρ is rate of pure time preference (if any), θ is the elasticity of marginal utility with respect to income, and g is rate of growth of consumption *per capita*. Approximately, $\rho = -\ln \delta$, so that $\rho = 0$ implies equal treatment of present and future.

In this lecture, population change will be ignored. If population growth is taken as exogenously given, the extension of the analysis is straightforward and does not give rise to any considerable differences. .

4. PURE TIME PREFERENCE

In formula (2), the second term, θg, is, I think, fairly uncontroversial. If future individuals are going to be better off than we are, then our willingness to sacrifice on their behalf is certainly reduced. It would require a greater rate of return to justify our depriving ourselves of consumption.

But the presence of pure time preference, denoted by ρ, has been very controversial. The English economists, in particular, have tended to be very scornful of pure time preference. Pigou (1932, p. 25] stated rather politely that pure time preference " implies...our telescopic faculty is defective." Ramsey and Harrod were more morally assertive. Ramsey (1928, p. 261): "[I]t is assumed that we do not discount later enjoyments in comparison with earlier ones, a practice which is ethically indefensible and arises merely from the weakness of the imagination." Harrod (1948, p. 40): "[P]ure time preference [is] a polite expression for rapacity and the conquest of reason by passion."

Koopmans, who has in fact given the basic argument *for* discounting, nevertheless holds "an ethical preference for neutrality as between the welfare of different generations" (1965, p. 239). Robert Solow (1974, p. 9): "In solemn

conclave assembled, so to speak, we ought to act as if the social rate of time preference were zero."

A general principle which guides the formation of moral judgments is what many philosophers call *universalizability*. A moral proposition cannot distinguish among individuals as such; it may differentiate among individuals because of properties deemed morally relevant. One way of characterizing universalizability is that it is the view that would be taken by a distinterested spectator. It would seem to be a consequence of universalizability that all generations should be treated alike. It *is* relevant to take account of the fact that future generations will be richer (if that is the case) but not that they are simply further away in time. It is this judgment that lies behind the quotations above.

Koopmans in several classic papers (1960, 1964) gave a crushing answer; see also Brown and Lewis (1981) for a more general treatment. The argument seems recondite. Koopmans considers a world which lasts forever. Therefore choice (including ethically-based choice) is based on a preference ordering over infinite-demensional consumptions streams. He argues that if the ordering is continuous and also sensitive (i.e., if one stream is never worse than another and is better at one or more time points, then it must be strictly preferred), it must display impatience.

A simple restatement of his reasoning can bring out the essential point. I confine myself to the intertemporally separable case. Imagine initially that output consists of a constant stream of completely perishable goods. There can be no investment by definition. Now imagine that an investment opportunity occurs, available only to the first generation. For each unit sacrificed by them, a perpetual stream of α per unit time is generated. If there were no time preference, what would the optimal solution be? Each unit sacrificed would yield a finite utility loss to the first generation, but to compensate there would be a gain, however small, to each of an infinity of generations. Thus *any* sacrifice by the first generation is good. Strictly speaking, we cannot say that the first generation should sacrifice everything, if marginal utility approaches infinity as consumption approaches zero. But we can say that given any investment, short of the entire income, a still greater investment would be preferred.

I think it is fair to say that this implication is unacceptable. We can generalize. Not merely is saving arbitrarily close to 100% unacceptable but very high sacrifices are also. I call this the *weak Koopmans argument*. This will meet a possible objection to the argument of the last paragraph. The proposed investment opportunity set is indeed very artificial. If the investment is feasible today, it should also be feasible in all future periods. From the perspective of the logic of choice, this is not a valid objection. If a preference ordering is suitable and meaningful, then it should explain behavior under any physically possible opportunity set, not merely "realistic" ones. In the usual theory of

choice which serves as a basis for competitive equilibrium theory, we assume it possible to make choices between pairs of alternatives, although in the application we see only choices within budget sets.

But let me waive this defense. Take time to be continuous. Suppose in fact that the investment opportunity described is available in every period. This is the standard pure capital model. To get a definite result, assume that utility is intertemporally additive and that the felicity function (utility in any one period) is a power function,

$$U(c_t) = c_t^{1-\theta}/(1-\theta),\ \theta > 1. \qquad (3)$$

In the absence of pure time preference, the maximand is the integral of $U(c_t)$ over the infinite horizon. (The assumption $\theta > 1$ implies an upper bound to U and therefore permits, in suitable cases, the existence of an optimum.) Under the assumptions made, the opportunity sets for each period are, of course, characterized by the differential equation,

$$dK/dt = \alpha K_t - c_t. \qquad (4)$$

where K_t is capital or accumulated savings at time t, α is output per unit capital, and K_0 is given. This case was already analyzed in Ramsey's original paper (1928, p. 276]), He showed that the optimal savings ratio (that is, ratio of savings to *income*) is $1/\theta$ (*independent* of the productivity α).

Reasonable estimates of θ are, of course, hard to come by, but there have been a few attempts; see the IPCC chapter on discounting, cited as Arrow et. al., (1996, p. 236)). They find that θ is 1.5 or less. If this were so, then the implied savings rate is 2/3 or more.

I find this to be an incredible and unacceptable strain on the present generation. Even Ramsey (1928, p. 278) remarks, after calculating savings ratios in a pure capital model for several plausible values of the elasticity of the marginal utility, θ: "The rate of saving which the rule requires is greatly in excess of that which anyone would normally suggest."

I therefore conclude that the strong ethical requirement that all generations be treated alike, itself reasonable, contradicts a very strong intuition that it is not morally acceptable to demand excessively high savings rates of any one generation, or even of every generation.

We must accept that the pure rate of time preference is positive. When Ramsey was in a less moral mode, he in fact agreed. Before a group of friends at Cambridge (the Society, frequently referred to as the Apostles), he spoke about the meaning of our observations of the universe. "My picture of the world is drawn in perspective. ... I apply my perspective not merely to space but also to time. In time the world will cool and everything will die; but that is a long way off still, and *its present value at compound interest is almost nothing.*" (Ramsey (1931, p. 291); emphasis added).

It will take more analysis than I have given thus far to come to a more definite figure for the pure rate of time preference and therefore for the social rate of discount. Very tentatively, it would seem that the pure rate of time preference should be about 1%. If one accepts a figure of 1.5 for the elasticity of the marginal utility of income, θ, and extrapolates the present growth rate of of *per capita* income, g, about 1.2%, then formula (2) would lead to a social rate of discount slightly under 3%. I tend to be a little more optimistic about future economic growth, perhaps because the fruits of the information and telecommunications revolutions have not been realized. If we assume something more like the historical rate of growth in *per capita* of 2%, the social rate of discount comes out to something in the neighborhood of 4%.

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5. AGENT-RELATIVE ETHICS: TIME CONSISTENCY AND INCONSISTENCY

Though the argument for pure time preference is very strong, it does not completely dispose of the intuition that morality requires that all generations should be treated alike. In this last section, I propose a point of view for which there is already precedent in the literature. Note that the standard formulation of discounted utilitarianism, given in (1) is *time-consistent*. If it embodies the value held by every generation, then each generation will make the same saving decisions as would be desired by the previous generations.

Discounted utilitarianism is not, as we have seen, consistent the basic moral principle of universalizability,. It reflects, in part, a principle of self-regard, of the individual as an end and not merely a means to the welfare of others. In a

favorite quotation of mine, Hillel, the first-century rabbi, asked, "If I am not for myself, then who is for me? If I am not for others, then who am I? If not now, when?". One can only say that *both* the universal other and the self impose obligations on an agent. Ethical obligation is therefore *agent-relative*, in the terminology of Samuel Scheffler (1982).

I come to the conclusion that it is not necessarily obligatory to fully comply with impersonally moral obligation. I have found, not surprisingly, that this point has been made by others, most especially the philosopher Scheffler ([1982; revised edition, 1994]; see also the anthology of writings on this issue edited by Scheffler [1988]).[1] The same point has been suggested in passing by

Yew-Kwang Ng (1989, p. 243). In fact, I had earlier formulated a model of intragenerational income redistribution in which the welfare of each individual was the utility of private consumption plus the sum of private utilities of all other individuals, the utilities for each individual being scaled so that at a given income level, the marginal utility for self was higher than that for others (Arrow 1981). "Morality" here consisted of treating *everyone else* equally, and there was indeed a tradeoff between individual welfare and moral obligation.

In the intergenerational context, it is important to note that the agent in each generation is that generation, not the set of all generations beginning with that one. Hence, agent-relative ethics suggests that each generation will maximize a weighted sum of its own utility and the sum of utilities of all future generations, with less weight on the latter. At the very least, really distant

generations are treated all alike. Now this is precisely the outcome of the questionnaire study of Cropper, Aydede, and Portney (1994); respondents weight returns one hundred years from now very little more than those two hundred years from now, although exponential discounting would lead to a very different outcome. From a theoretical perspective, Chichilnisky (1996) has given a plausible set of axioms on individual attitudes to the future which lead to results similar to those of Cropper, Aydede, and Portney.

However, this is not the end of the story. It gives a way of understanding the welfare function of any one generation. But no one generation controls the future. Each generation can determine how it will divide its disposable income among consumption and various kinds of investments, public or private. But the next generation will have the same decision. If all investment is short-lived (or, more generally, reversible), then all that one generation can determine is how much capital to pass on to its immediate successor. That generation in turn will decide what it will leave to the next and so forth.

Hence, what one generation leaves will be influenced by its expectation of what the next generation will do with its income, which is wholly or partly determined by what the first generation gives it. The second-generation allocation (as a function of the capital it receives) will determine the utility of the first generation's bequest to the latter and therefore determine (in part) the amount the first generation will leave.

This becomes a game among the successive generations, which has already been analyzed in the classic paper by Phelps and Pollak (1968). I will not analyze the details of the solution here, though I believe they have very interesting implications for setting discount rates. But there is one point which emerges clearly. The future, looked at from each point, looks the same, except possibly for a different initial capital stock. Then the actual equilibrium path is more or less what it would be with some particular discount rate; at least this is true if the felicity functions are power functions. Even though no individual discounts the future exponentially, the equilibrium path will be that corresponding to an exponentially discounted path.

The agent-relative analysis of ethical obligation to the future therefore provides a foundation for the positivity of pure time preference.

NOTES

[1]I am indebted to Derek Parfit for the references to Scheffler's work.

[2] Dasgupta (1974) has developed a similar game interpretation to develop a theory of just savings along Rawlsian lines.

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