Intergenerational Solidarity, Welfare and Human Ecology
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INTERGENERATIONAL WELL-BEING

PARTHA DASGUPTA

Prologue

In this essay I provide an account of the way welfare economists have tried – literally over decades – to consider some of the crucial problems that arise when we try to come to grips with notions of *Intergenerational Solidarity, Welfare, and Human Ecology*. The subject is huge and much has been written on it. So I am selective, the choice in great measure reflects my own engagements and ability.

The philosopher Derek Parfit (Parfit, 1984) has classified problems in social ethics in terms of the domain of persons who fall within the range of consideration. His classification is three-fold: Same People Problems, Same Numbers Problems, and Different Numbers Problems.

When we deliberate over policies that would affect the *same* group of people (for example, parents choosing the allocation of food and health care within their household), we are in the realm of a Same People Problem. In discussing intergenerational solidarity, however, we are not in the realm of Same People Problems, because what we do today would be expected to have an effect on the *identities* of future generations, even if it does not have an effect on future numbers. For example, it could be that future numbers are *un*affected by choice from among the policies under consideration, but the exact timing of conceptions are expected to be affected. In this case we are faced with a Same Numbers Problem. If, however, future numbers *are* affected, we have a Different Numbers Problem.

In an intergenerational Same Numbers Problem, alternative policies are evaluated in terms of their impact on 'present' and 'future' people. 'Present' people are alive now; 'future' people aren't alive now, but will be alive in the future. Demographers refer to 'present' people when informing us that a country's population has passed the one-billion mark. They

include 'future' people in their reckoning when issuing a forecast that the world's population will be 9.5 billion in 2050.

Discussions on economic policy usually presuppose a forecast of future numbers; which is to say that policy discussions are usually undertaken on the assumption that the choices involve Same Numbers Problems. This is obviously a simplification, for it is hard to imagine any economic policy that does not have an influence on future numbers; however, since it is a good approximation in many cases to imagine this, much policy discussion is based on it. This essay is devoted to the ethics of Same Numbers Problems. I had originally thought of adding a few sections on Different Numbers Problems.

But I have resisted the temptation, because the subject is immensely difficult: it calls for a framework that includes in our ethical deliberations *potential* people and, so, potential lives. It may be that at the Plenary, fellow Academicians will wish to discuss Different Numbers Problems. If that is so, I shall be happy to sketch what there is in the economics literature on the subject.

A preliminary observation: An individual's lifetime well-being is a construct of the flow of current well-being she experiences, while intergenerational well-being is a construct of the lifetime well-beings of all who appear on the scene. It is doubtful that the two constructs have the same functional form. On the other hand, I know of no evidence that suggests we would be way off the mark in assuming they do have the same form. As a matter of practical ethics, it helps enormously to approximate by not distinguishing the functional form of someone's well-being through time from that of intergenerational well-being. In what follows, I take this short-cut.

1. *The Ramsey Formulation*

We assume that the demographic profile over time is given. The problem is to strike a balance between the well-being of present and future generations, keeping in mind that there is a corresponding set of allocation problems arising from the need to strike a balance in every person's lifetime well-being. Intergenerational welfare economics was established in Ramsey (1928), a classic that reads as though it could have been written last week. The problem Ramsey formulated was a particular one: of its total output, how much should a nation save for the future? Ramsey interpreted his theory along the lines of Classical Utilitarianism. (For example, he used the term 'enjoyment' to refer to what I am referring to as well-being.)

Nevertheless, the framework he developed for analysing the problem of optimum saving has subsequently been found to have wide applicability, regarding both interpretation and issues – so wide, in fact, that within modern economics there is no rival framework for studying the intergenerational distribution of benefits and burdens. Here I offer an account of Ramsey's theory and its interpretive extensions, without having any necessary commitment to Classical Utilitarianism. Let τ and t alternatively denote *dates*, where $\tau \geq t \geq 0$ (and 0 denotes the present). It helps to interpret the period between adjacent dates as the length of a generation. One can imagine that at the end of each period the existing generation is replaced entirely by its successor. This isn't good demography, but it turns out not to matter. Every ethical consideration that emerges here makes an appearance also in worlds where demography is modeled better. Moreover, better models of demography would not raise any ethical issue that doesn't appear here. Population size is assumed to be constant and the future is taken to be indefinitely long. Later I relax these assumptions. For simplicity of exposition, I consider a deterministic world. Let Ut denote generation t's well-being and let V_t denote *intergenerational well-being, as viewed from date t*. Ramsey's theory has it that we should regard V_t to be the sum of the Us from t onward into the indefinite future. Formally, this means that

$$V_t = U_t + U_{t+1} + ...,$$

which I write succinctly as,

$$V_t = \sum_{t}^{\infty} U_\tau, \text{ for } t \geq 0. \tag{1}$$

Let us now put some economic flesh into the construct. I imagine that each generation's well-being (U) depends on the flow of some generalized consumption, which I call C. C includes food, clothing, shelter, health care, serenity, leisure activities, legal aid, and various types of public goods (including civil and political liberties and direct amenities from the natural environment). The various components are weighted so as to reflect their distribution among people of each generation. I take it that U increases with C.

As population is assumed to be constant, I ignore its size and regard a generation's aggregate consumption as the determinant of that generation's well-being. So, C does all the work in representing the determinants of *intra*generational well-being. The move makes for expositional ease. It enables me to concentrate on intergenerational matters.

Denote generation t's well-being as $U(C_t)$. As in (1), *intergenerational well-being*, or *social well-being* for short, is taken to be the sum of each generation's well-being. Let $(C_t, C_{t+1}, ...)$ be a *consumption stream*, which is a sequence of aggregate consumption from t onward. Denoting social well-being at t by V_t, Ramsey's theory has it that:

$$V_t = U(C_t) + U(C_{t+1}) + ...,$$

which I write succinctly as,

$$V_t = \sum_{t}^{\infty}(C_\tau), \text{ for } t \geq 0. \tag{2}$$

The present is taken to be $t = 0$. Ramsey's problem was to identify, within the set of feasible consumption streams, the one that maximizes V_0.[1]

[1] The account in its entirety, which can be skipped by fellow Academicians, if they so choose, is as follows: Generation *0* has inherited from its predecessors a wide range of capital assets, including natural resources and knowledge. Given this inheritance, the generation is able to select from a set of feasible consumption streams. Call this feasible set Ξ_0. Imagine now that $(C_0, C_1, ..., C_t, ...)$ is that member of Ξ_0 which maximizes V_0. Ramsey's theory calls upon generation *0* to consume C_0. This simultaneously leads to an investment decision, which in turn determines the technological possibilities that are open to generation 1. Denote the feasible set of consumption streams for generation 1 to be Ξ_1.

A typical member of Ξ_1 can be written as $(C_1, C_2, ..., C_t, ...)$. The problem facing generation 1 would be to identify that element of Ξ_1 that maximizes V_1. It is an interesting and important feature of expression (1) that generation 1 would identify the optimum consumption stream to be $(C_1, C_2, ..., C_t, ...)$. Plainly, then, generation 1 would consume C_1, invest accordingly, and pass on the optimum stocks of capital assets to generation 2. And so on. The ethical viewpoints of the succeeding generations are congruent with one another. Each generation chooses the policy it deems optimum, aware that succeeding generations will choose in accordance with what it had planned for them.

Comment: Ramsey's assumption that the future is infinite feels odd. We know that the world will cease to exist at some date in the future. So it would seem realistic to stipulate a finite horizon, say T periods, where the chosen T is large. The problem is that no matter how large T is, there is some chance that the world will survive beyond T. An alternative to Ramsey suggests itself: specify the capital stocks that are to remain at T for generations still to appear, and interpret social well-being to be the Tperiod sum of current well-beings and the size of the capital base remaining at T.

There is a problem even with this formulation. If T and the capital base that remains at T are chosen arbitrarily, the consumption stream deemed the best could be sensitive to the choice. This means that T and the capital stocks at T should not be chosen arbitrarily, but should be based on our understanding of what lies beyond T (for example, the needs

The point to which I want to draw attention is that in Ramsey's formulation future values of *U* are *un*discounted. More than any other feature of his theory, it is this that has provoked debate among economists and philosophers. Ramsey himself wrote (1928: 261) that to discount later *U*s in comparison with earlier ones is '... ethically indefensible and arises merely from the weakness of the imagination'.

Harrod (1948: 40) followed suit by calling the practice a '... polite expression for rapacity and the conquest of reason by passion'.[2]

But there is a problem with zero discounting. In such complex exercises as those involving the use of resources over a very long time horizon, it is *unsafe* to regard any ethical judgment as sacrosanct. This is because one can never know in advance what it may run up against. A more judicious tactic than Ramsey's would be to play off one set of ethical assumptions against another in not implausible worlds, see what their implications are for the distribution of well-being across generations, and then appeal to our intuitive senses before arguing over policy.

Consider, for example, the following ethical tension:

A) Low rates of consumption by generations sufficiently far into the future would not be seen to be a bad thing by the current generation if future well-beings were discounted at a positive rate. This suggests we should follow Ramsey in not discounting future well-beings.

B) As there are to be a lot of future generations in a world with an indefinite future, not to discount future well-beings could mean that the present generation would be required to do too much for the future; that is, they would have to save at too high a rate. This suggests we should abandon Ramsey and discount future well-beings at a positive rate.[3] The force of each consideration has been demonstrated in the economics literature. For example, it has been shown that in an economy with exhaustible resources and 'low' productive potentials, optimum consumption declines to zero in the long run if the future is discounted at a positive rate, no matter how low the chosen rate (Dasgupta and Heal, 1974), but increases indefinitely if we follow Ramsey (Solow, 1974a). This finding was the substance of Solow's remark

of those who may appear after *T*). But then, why not include their claims in the planning exercise to begin with; why truncate the future into two bits? The route Ramsey followed, of regarding the future to be indefinitely long, is logically unavoidable; for, although we know that the world will not exist for ever, we don't know when it will cease to exist.

[2] Their position has been re-examined and endorsed by a number of modern philosophers; see Feinberg (1980), Parfit (1984), Goodin (1986), and Broome (1992).

[3] By 'discounting the future', I mean the same thing as 'discounting future well-beings'.

(1974b) that, in the economics of ecological resources, whether future well-beings are discounted can be a matter of considerable moment. In recent years, environmental and resource economists writing on sustainable development have taken this possibility as their starting point. On the other hand, it has been observed that Ramsey's ethical theory, when applied to the model economy he studied in his paper, can recommend that every generation save at a very high rate. For classroom exercises, the optimum saving rate has been calculated to be in excess of 60 percent of gross national product. In a poor country such a figure would be unacceptably high, requiring the present generation to sacrifice beyond the call of duty. The real problem is that we don't know in advance how to formulate the problem of intergenerational saving. The issues are far too complex. Unaided intuition is suspect.

However, another way to interpret Ramsey's finding would be to acknowledge that we don't know the correct way to formulate the ethics of intergenerational saving, but that Ramsey's formulation is a-priori plausible. If, on putting it through its paces in plausible economic models, it is found to prescribe acts that are too demanding for the current generation, the formulation ought to be rejected on grounds that it doesn't capture the right balance between the claims of the present generation and those of future ones. The insight one obtains from quantitative exercises is that the long-run features of optimum consumption policies depend on the relative magnitudes of the rate at which future well-beings are discounted and the long-term productivity of capital assets.

2. *Discounting the Future*

In a remarkable series of articles, Koopmans (1960, 1965, 1967, 1972) showed that consideration B above can overwhelm the Ramsey-Harrod stricture.[4] The stricture can imply that there is no best policy; that, no matter how high is the rate of saving, saving a bit more would be better. To see how and why, imagine a world where goods are completely perishable. We imagine that well-being U would increase if consumption C were to increase. Consider an economic programme where consumption is the same at every date. Now imagine that an investment opportunity presents itself in which, if the present generation were to forgo a unit of consumption, a perpetual stream of additional consumption μ (> 0) would be generated.[5] Suppose

[4] For a simple account of Koopmans's theory, see Dasgupta and Heal (1979: ch. 9). The exposition that follows in the text is taken from an even simpler account in Arrow (1999).

[5] This means that the rate of return on investment is μ.

social well-being is represented by expression (2). Then, no matter how small μ is, future generations, taken together, would experience an infinite increase in well-being as a consequence of the investment. (μ 'multiplied' by infinity is infinity.) So, for any level of consumption, no matter how low, a further reduction in consumption (possibly short of a reduction that brings consumption down to zero) would be desirable. Most people would regard this as unacceptable.

In consequence of this kind of paradox, Koopmans adopted a different research tactic from Ramsey. Social well-being in Ramsey's theory is the sum of utilities [equation (1)]. Ramsey's ranking of consumption streams [expression (2)] is derived from the sum of utilities. In contrast, the primitive concept in Koopmans's theory is that of a ranking of consumption streams. Koopmans's tactic was to impose ethical conditions on such rankings and to determine, if possible, the way they can be represented numerically. Social well-being in Koopmans's theory is a numerical representation of a ranking of consumption streams.

Koopmans (1960, 1972), and in a related manner P.A. Diamond (1965), showed that, if an ordering over well-being streams satisfies two minimal ethical properties, it must involve positive discounting.[6] Koopmans also identified a set of additional ethical conditions on consumption streams which imply that their numerical representations are of the form:

$$V_t = \sum_{t}^{\infty} \beta^{(\tau-t)} U(C_\tau), \text{ for } t \geq 0, \text{ where } \beta \equiv 1/(1+\delta), \text{ with } \delta > 0. \qquad (3)$$

In equation (3) U is interpretable as current well-being. $\beta^{(\tau-t)}$ is the *discount factor* and δ the corresponding *discount rate*; δ is often called the 'rate of pure time preference'. Estimates of the costs and benefits of restricting global carbon emissions depend crucially on the choice of β (respectively, δ).[7]

While expression (3) looks like Classical Utilitarianism with discounting, it is not. U doesn't necessarily have the interpretation of utility, in the sense of the Classical Utilitarians. Koopmans's axioms lend themselves to a broader range of interpretations, which is an attraction.

It is an agreeable feature of Koopmans's theory that, as in Ramsey's theory, the ethical viewpoints of the succeeding generations are congruent

[6] I resist elaborating on the ethical axioms here.

[7] Social discount rates were discussed at a previous Plenary of our Academy.

with one another. Each generation chooses that policy it deems optimum, aware that succeeding generations will choose in accordance with what it had planned for them.

3. *A Problem with Koopmans*

Imagine that we adopted Koopmans's formulation of intergenerational well-being [equation (3)], applied it to a deterministic model of production and consumption possibilities, and discovered that if the rate of pure time preference (δ) is positive, optimum consumption will decline to zero in the long run, no matter how small δ is. Suppose it is also discovered that if δ is sufficiently small – but not zero –, the decline in consumption will begin only in the distant future – the smaller is δ, the farther is the date at which consumption will begin to decline.[8] Should Koopmans's formulation be rejected on the ground that it recommends an eventual decline in consumption?

Many would reject it on that very ground.[9] But I have never understood why. Models of a deterministic world with an infinite horizon are mathematical artifacts. They are meant to train our intuitions about economic possibilities in a world with a long, but finite, horizon, when we are loath to specify the termination date, and are also loath to acknowledge that it has an uncertain date. The models must not be taken literally, because Earth will not last forever. We cannot, of course, know now when Earth will cease to exist, but we do know that it will cease to exist *by* some date, say, 10^{12} years. (That's 1 trillion years; and Earth is a bit over a mere 4 billion years old). Suppose, for example, that we were to set δ equal to 10^{-n} per year and were to choose n sufficiently large, so that optimum consumption in the kind of deterministic model I have been considering would have a turning point in, say, year 10^{30} (that's a billion billion trillion years). Should we care that consumption in the model will decline from year 10^{30}? I know of no reason why we should. On the contrary, justice would be ill-served if all generations were asked to save for a vacuous posterity. As an articulation of the concept of intergenerational well-being, Koopmans's theory is compelling.

[8] This has been shown to be the case in simple economic models involving exhaustible resources. See Dasgupta and Heal (1979: ch. 10).

[9] For example, Heal (1998). Earlier, I called it consideration *A*.

4. *Population Growth*

Since Earth is finite, changes in the size of population when averaged over time will be zero over the very long run. The base case we have been considering so far, that population size remains constant, is thus valid when the reckoning is the very long run. But for the not-so-very long run, population can be expected to change. How should the notion of intergenerational well-being be formulated when population size changes over time? Two alternatives have been much discussed in the literature. Both reduce to the Ramsey-Koopmans formulation if population is constant. After presenting them I introduce a third formulation. It too reduces to the Ramsey-Koopmans formulation if population is constant. One alternative is to regard the well-being of a generation to be the per capita well-being of that generation (with no allowance for the numbers involved) and sum the per capita well-beings of all generations, possibly using a discount rate. To formalize, let *ct* be the index of aggregate consumption per head at *t*, and let *U*(*ct*) denote well-being per head of generation *t*. We then have,[10]

$$V_t = \sum_{t}^{\infty} [U(c_\tau)]\beta^{(\tau-t)}, \text{ for } t \geq 0, \text{ where } \beta \equiv 1/(1+\delta), \text{ with } \delta > 0. \qquad (4)$$

The other view is to interpret social well-being as the sum of the discounted flow of each generation's well-being. Specifically, if *Nt* is the size of generation *t*, and *ct* the average consumption level of generation *t*,[11]

$$V_t = \sum_{t}^{\infty} [N_t U(c_\tau)]\beta^{(\tau-t)}, \text{ for } t \geq 0, \text{ where } \beta \equiv 1/(1+\delta), \text{ with } \delta > 0. \qquad (5)$$

Expression (4) regards people, not generations, to be the subject. In contrast, expression (5) regards generations, not people, to be the subject. To see in which ways their recommendations differ, imagine an economy in Utopia consisting of two islands, with populations N_1 and N_2. People in Utopia are identical. A person's well-being is denoted by *U*, which increases with consumption, but at a diminishing rate. There is a fixed amount of consumption services, that the government has to distribute.[12] Let C_1 and C_2 be the amounts distributed to the two islands. As the economy is in Utopia, it is to be expected that, no matter how much is awarded to each island, the distri-

[10] See Cass (1965) and Koopmans (1965).
[11] See Meade (1955), Mirrlees (1967), and Arrow and Kurz (1970).
[12] The example is taken from Meade (1955: 87-89) and Arrow and Kurz (1970: 13-14).

bution of consumption *within* each will be equal. The economy is timeless.

If numbers count, then analogous to (5), social well-being would be $[N_1U(C_1/N_1) + N2U(C_2/N_2)]$ and the government would distribute in such a way that consumption is equalized among all citizens.

This is obviously the right allocation, because geographical differences are an artifact for the problem in hand. On the other hand, if numbers don't count, so that social well-being is taken to be $[U(C1/N1) + U(C2/N2)]$, the Utopian government would distribute less to each person in the more populous island. Analogously, the use of (4) discriminates against more numerous generations. This simply cannot be right. Of (4) and (5), the latter reflects the notion of intergenerational well-being more adequately. Expression (5) measures *total* well-being of all who will ever live. It is of the same form as Classical Utilitarianism. But there is yet another way to formulate the concept of intergenerational well-being: it reflects the *average* well-being of all who are to appear on the scene. This has an attractive ethical basis: choice under uncertainty.

The idea is to regard an economy at t to be a different economy from that same economy at $t+1$. Now suppose you were asked which of the two economies you would choose to inhabit if you did not know which person's shoes you would occupy in either, but attributed 'equi-probability' to each position.[13] Imagine next that in this thought experiment your choice is based on your *expected well-being* in the two economies. Expected well-being in the economy commencing at t is,

$$V_t = \{\sum_{t}^{\infty} [N_t U(c_\tau)]\beta^{(\tau-t)}\}/\{\sum_{t}^{\infty} N_\tau \beta^{(\tau-t)}\}, \text{ for } t \geq 0,$$
$$\text{where } \beta \equiv 1/(1+\delta), \text{ and } \delta \geq 0.^{14} \qquad (5)$$

Notice that V_{t+1} is of the same form as Vt, with ô commencing at t+1 in (6). You would choose between the two economies on the basis of Vt and V_{t+1}. This is the ethical justification of expression (6). Dasgupta (2001),

[13] See Harsanyi (1955). I have qualified equi-probability in the text because it makes no sense when the future has no termination. To give it sense we must suppose that the probability of extinction over the indefinite future is unity. We may then talk of equi-probability of the conditionals. We discuss this in the following section. See also Dasgupta and Heal (1979: ch. 9).

[14] Notice that in t+1 the only shoes you will not have to consider are the ones that belonged to those of generation t.

Arrow, Dasgupta, and Mäler (2003), and Arrow, Dasgupta, Goulder, *et al*. (2004) have shown that expression (6) is the natural concept of intergenerational well-being if we were to deliberate over the notion of *sustainable development*, namely, the requirement that *Vt* does not *decline* as *t* increases. Notice though that, once we are given the population forecast, the denominator in (5) is independent of the policies that could be chosen at *t*. This means that a policy deemed to be *optimal* if (5) were used as the criterion of choice would also be judged to be optimal if instead (6) were used as the criterion of choice. For Ramsey the two expressions would amount to the same. However, they would be seen to differ if we wished to determine whether a policy is *sustainable*. This poses no paradox: *Optimality and sustainability are different concepts, serving different purposes*.

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