Interpreting Sustainability in Economic Terms: Dynamic Efficiency Plus Intergenerational Equity

Robert N. Stavins, Alexander F. Wagner, and Gernot Wagner

August 2002 • Discussion Paper 02–29

RESOURCES FOR THE FUTURE

Resources for the Future
1616 P Street, NW
Washington, D.C. 20036
Telephone: 202–328–5000
Fax: 202–939–3460
Internet: http://www.rff.org

Interpreting Sustainability in Economic Terms: Dynamic Efficiency Plus Intergenerational Equity

Robert N. Stavins, Alexander F. Wagner, and Gernot Wagner
Harvard University

Cambridge, Massachusetts
May 14, 2002

Robert N. Stavins
John F. Kennedy School of Government
Harvard University
Cambridge, MA 02138
Phone: (617) 495-1820
robert_stavins@harvard.edu

Alexander F. Wagner
Department of Economics
Harvard University
Cambridge, MA 02138
Phone: (617) 945-2865
awagner@fas.harvard.edu

Gernot Wagner
79 JFK Street, B405
Cambridge, MA 02138
Phone: (617) 495-0833
Fax: (617) 495-1635
gwagner@post.harvard.edu

Interpreting Sustainability in Economic Terms: Dynamic Efficiency Plus Intergenerational Equity

Robert N. Stavins, Alexander F. Wagner, and Gernot Wagner*

Economists have expended considerable effort to develop economically meaningful definitions of the somewhat elusive concept of "sustainability." We relate such a definition of sustainability to well known concepts from neoclassical economics, in particular, potential Pareto improvements (in the Kaldor-Hicks sense) and inter-personal compensation. In the inter-temporal realm, we find that dynamic efficiency is a necessary but not sufficient condition for a notion of sustainability that has normative standing as a goal for public policy. We define sustainability as dynamic efficiency plus intergenerational equity. Further, we argue that it is not unreasonable for economists to focus on the efficiency element, leaving equity considerations to the political process. The analogy to the relationship between potential Pareto improvements and (intragenerational) transfers can facilitate discussions about sustainability, both within the economics community and as part of an interdisciplinary discourse, and makes the basic concepts easier to operationalize.

1. Introduction

There has been much debate among economists, and between economists and nearly everyone else regarding the meaning of the frequently employed concept of "sustainability." In this note, we suggest that a broadly-accepted and normatively useful notion of sustainability can be better understood by breaking it into two components, both of which are well defined in economics: dynamic efficiency and intergenerational equity. Within this realm, there are sound reasons for economists to focus on policy criteria associated with the dynamic efficiency element of sustainability.

In 1987, the Brundtland Commission placed sustainability on international political and scientific agendas with its report, "Our Common Future" (World Commission on Environment and Development 1987). The Commission proposed the widely embraced definition that

* Stavins is the Albert Pratt Professor of Business and Government, John F. Kennedy School of Government, Harvard University, and a University Fellow of Resources for the Future; Alexander Wagner is a Ph.D. student in Political Economy and Government at Harvard University; and Gernot Wagner is a B.A. student at Harvard College. We thank Geir Asheim, Partha Dasgupta, John Hartwick, John Pezzey and Martin Weitzman for helpful comments on an earlier draft. The authors are responsible for any remaining errors.

"development is sustainable when it meets the needs of the present without compromising the ability of future generations to meet theirs" (WCED 1987). This is the definition we use as our starting point. We find that – contrary to some claims – sustainability is *not only* about intergenerational equity; rather, widely-held views of sustainability encompass elements of both efficiency and distributional equity. Furthermore, much as economists have long focused on potential rather than actual Pareto improvements, they need not be apologetic for focusing on dynamic efficiency, leaving (admittedly important) equity considerations to the political process.

2. Dynamic Efficiency

The definition of sustainability offered by the World Commission on Environment and Development (WCED) is broadly accepted and seems to have intuitive appeal: meeting the needs of the present without compromising the ability of future generations to meet their needs. In the absence of efficiency, constant consumption at no more than a subsistence level could satisfy this requirement, yet it would surely not be accepted as a reasonable social goal or target for public policy. Any appealing normative criterion for public policy in this domain ought to include some notion of "non-wastefulness." That is, a meaningful definition of sustainability which has normative standing as a social goal ought to include dynamic efficiency, expressed formally as the maximization of

$$W(t) \equiv \int_t^\infty U\big(\mathrm{c}(\tau)\big)\, e^{-r(\tau-t)} d\tau, \qquad (1)$$

over all feasible alternative consumption paths $\mathrm{c}(\tau)$, where $U\big(\mathrm{c}(\tau)\big)$ denotes the most general, idealized utility function comprising both direct consumption as well as the enjoyment of nonmarket goods and services, and □ is the social rate of time preference.[1] If it is desirable to avoid unnecessarily degrading resources, and if sustainability has normative standing as a policy goal, then dynamic efficiency is a necessary condition for a normatively meaningful interpretation of this concept.

The important point here is that $W(t)$ must capture total welfare. Anything else can be misleading. Omitting contributions to welfare of any kind of capital will lead to an underestimate of the total value of $W(t)$, and omitting any form of capital depreciation will lead to an overestimate. The theoretical implications of technological and population change have been examined in this context, and the theory regarding ideal measures of $W(t)$ has been explored extensively.[2]

3. Intergenerational Equity

Although we have argued that dynamic efficiency is necessary for a normatively useful definition of sustainability, we do not believe that dynamic efficiency is a sufficient condition for sustainability.[3] It is also essential for consistency with widely embraced definitions of this concept that the maximized total welfare function not decrease over time. Formally, an optimized consumption path fulfills the condition of intergenerational equity if

---

[1] This formulation as well as the notation used in equation (2) are consistent with Arrow *et al*. (2002), which calls the solution of this problem the "present value of felicities." Weitzman (2002) refers to it as a measure of "welfare-equivalent sustainability."

[2] Pezzey and Toman (2001) provide a survey of these issues. Heal (1998, 2001), Solow (1991), and Weitzman (2002) also give reasons why narrow definitions of "economic" capital should be expanded to include, for example, human and natural capital.

[3] In fact, sustainability has frequently been defined as being exclusively about intergenerational equity. Most recently, Arrow *et al*. (2002) make a clear distinction between optimality as the "discounted present value of future well being" as presented in equation (1) and sustainability, defined as "the maintenance or improvement of well being over time," formally presented in equation (2). One exception in the current literature is Asheim, Buchholz and Tungodden (2001), who impose so-called efficiency and equity axioms and show that if social preferences fulfill these two axioms, any optimal path will lead to an efficient and non-decreasing path, thus implicitly including dynamic efficiency in the definition of sustainability. For an earlier discussion of sustainability and optimality, see Pezzey (1992).

(2) $$\frac{dW(t)}{dt} \geq 0,$$

where $W(t)$ represents the maximized total welfare function from equation (1).

This brings us to an economic definition of sustainability: an economy is sustainable if and only if it is dynamically efficient and the resulting stream of maximized total welfare functions is non-declining over time.

4. Sustainability

We acknowledge that the above definition provides a demanding pair of decision criteria that cannot be considered to be very useful as a guide for public policy. The same is true, however, of the benchmark of a Pareto-improving policy — one which makes some members of society better off, but makes *no one* worse off (1896). Actual Pareto improvements are exceptionally rare, of course, perhaps even non-existent. Hence, the strict Pareto criterion is virtually never taken as a guide for public policy, despite its considerable normative appeal. Economists resort instead to seeking "potential Pareto improvements" in the Kaldor-Hicks sense — the world is viewed as being made better off if the magnitude of gains and the magnitude of losses are such that the gainers can fully compensate the losers for their loses and still be better off themselves.[4] Note that under the Kaldor-Hicks criterion, the change is considered to be an improvement whether or not the compensation actually takes place. Actual compensation of losers by winners is essentially left to the political process.

What is key is that the Kaldor-Hicks criterion is a necessary condition for satisfying the strict Pareto criterion. If a policy proposal fails the Kaldor-Hicks test, it cannot pass the Pareto test. If a proposed change is not a potential Pareto improvement, it cannot be a Pareto

[4] The notion that a welfare improving change ought to be associated with a "potential Pareto improvement" was introduced by Kaldor (1939) and Hicks (1940).

improvement. This is the fundamental theoretical foundation — the normative justification — for employing benefit-cost analysis, that is, for searching for policies that maximize the positive difference between benefits and costs.

Similarly, we can think of an economy as having the *potential* to become sustainable if it fulfills the criterion of dynamic efficiency. It can then, in principle, be made sustainable by appropriate intergenerational transfers to achieve a non-declining total welfare path. One such economy that *can* be made sustainable has been formalized by Hartwick (1977), in which there exists the *possibility* of turning exhaustible resources into capital stock, a particular type of intergenerational transfer. If the Hartwick rule of investing all rents from exhaustible resources in reproducible capital is followed, then the economy can be made sustainable.[5]

Much as economists have long focused on potential rather than actual Pareto improvements, leaving the allocation of net gains among individuals (and, hence, the resolution of debates regarding distributional equity) to the political process, similar reasoning leads to an analogous approach to the sustainability debate. In theory, it may be argued that sustainability is ultimately the most desirable policy goal, but in practice it is more reasonable to aim for potential sustainability in the form of dynamic efficiency (of an all-encompassing societal welfare function).[6]

[5] The conditions under which the Hartwick rule holds, however, are restrictive. Asheim and Buchholz (2000) further explore the assumptions under which the Hartwick rule holds.

[6] Except for the elusive case of the Hartwick economy, utility transfers between generations are difficult to operationalize. Their abstractness provide a further reason why we can make more useful policy statements by being satisfied with potential transfers.

We recognize that this opens an avenue for criticism of economics as being excessively focused on efficiency rather than equity, but the efficiency criterion and related analytical methods are — ultimately — where the greatest strengths of economics lie.[7]

5. Conclusion

Sustainability is a broad concept, but it does not need to be "vague," as Solow (1991) has argued. Interpretations that are acceptable both to natural scientists and economists should be possible. We find that sustainability can be conceptualized simply and clearly by employing a conventional economics framework, based on discounted utilitarianism. In short, a sustainable growth path is one which is both dynamically efficient and which is non-decreasing over time. Much as a potential Pareto improvement in the Kaldor-Hicks sense can yield Pareto optimality when combined with appropriate compensation of losers by winners, so too can dynamic efficiency lead to the more ambitious goal of sustainability when it is combined with appropriate intergenerational transfers. And much as economics often resorts to seeking potential Pareto improvements, leaving the final allocation to the political process, so too may it focus on dynamic efficiency, leading to the possibility, at least, of actual sustainability.

[7] One of the most prominent critiques of this focus of economics on efficiency has been offered by Sen (1970). He points out that a society may be efficient "even when some people are rolling in luxury and others are near starvation, as long as the starvers cannot be made better off without cutting into the pleasures of the rich. In short, a society can be Pareto optimal and still be perfectly disgusting." Our definition of sustainability does involve notion of distributional equity by including both dynamic efficiency and intergenerational equity. We argue only that the comparative advantage of economics lies in its focus on the first element, whereas the comparative advantage of politics lies in focusing on distributional considerations.

REFERENCES

Arrow, Kenneth; Daily, Gretchen; Dasgupta, Partha; Ehrlich, Paul; Goulder, Lawrence; Heal, Geoffrey; Levin, Simon; Mäler, Karl-Göran; Schneider, Stephen; Starrett, David and Walker, Brian. "Are We Consuming Too Much?" Discussion Paper, Beijer International Institute of Ecological Economics, Stockholm (February 2002).

Asheim, Geir; Buchholz, Wolfgang. "The Hartwick rule: Myths and facts." Discussion Paper, University of Regensburg (January 2000).

Asheim, Geir; Buchholz, Wolfgang and Tungodden, Bertil. "Justifying Sustainability." *Journal of Environmental Economics and Management* 41(3), 252–268 (2001).

Hartwick, John M. "Investment of Rents from Exhaustible Resources and Intergenerational Equity," *American Economic Review* 67(5), 972–974 (1977).

Heal, Geoffrey. "Valuing the Future: Economic Theory and Sustainability." Columbia University Press (1998).

Heal, Geoffrey. "Optimality or Sustainability." Plenary address to the annual conference of the European Association of Environmental and Resource Economists, Southampton (June 2001).

Hicks, John R. "The Valuation of the Social Income." *Economica* (New Series) 7(26), 105–124 (May 1940).

Kaldor, Nicholas. "Welfare Propositions of Economics and Interpersonal Comparisons of Utility." *The Economic Journal* 49(195), 549–552 (September 1939).

Pareto, Vilfredo. *Cours d'Economie Politique*, volume 2. Lausanne, (1896).

Pezzey, John C.V. *Sustainable Development Concepts: An Economic Analysis*. Washington, D.C.: World Bank. World Bank Environment Paper No. 2 (1992).

Pezzey, John C.V. and Toman, Michael A. "Progress and Problems in the Economics of Sustainability." Forthcoming in Tietenberg, Thomas H. and Folmer, Henk (Eds.). *International Yearbook of Environmental and Resource Economics 2002/2003*. Cheltenham: Edward Elgar. Draft copy (August 2001).

Sen, Amartya K. *Collective Choice and Social Welfare*. San Francisco: Holden-Day (1970).

Solow, Robert M. "Sustainability: An economist's perspective." The Eighteenth J. Seward Johnson Lecture to the Marine Policy Center, Woods Hole Oceanographic Institution, in Dorfman, Robert and Dorfman, Nancy S. (Eds.). *Economics of the Environment: Selected Readings*. New York: Norton. 179-187 (1991).

Weitzman, Martin L. *Income, Capital, and the Maximum Principle.* Draft copy, Harvard University (January 2002).

World Commission on Environment and Development. "Our Common Future." Oxford: Oxford University Press (1987).