

# **Sustainable Development— Definitions, Principles, Policies<sup>1</sup>**

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## **Introduction**

I begin by considering two competing definitions of sustainability, utility-based versus throughput-based, and offer reasons for rejecting the former and accepting the latter. Next, I consider the concept of development as currently understood (GDP growth led by global economic integration) and why it conflicts with sustainability, as well as with the premises of comparative advantage. Then, I turn to the more general necessity of introducing the concept of throughput into economic theory, noting the awkward consequences to both micro and macro economics of having ignored the concept. Finally, I consider some policy implications for sustainable development that come from a more adequate economic theory. These policies (ecological tax reform and/or cap and trade limits on throughput) are based on the principle of frugality first, rather than efficiency first.

## **Definitions**

Exactly what is it that is supposed to be sustained in ‘sustainable’ development? Two broad answers have been given:

First, utility should be sustained; that is, the utility of future generations is to be non-declining. The future should be at least as well off as the present in terms of its utility or happiness as experienced by itself. Utility here refers to average per capita utility of members of a generation.

Second, physical throughput should be sustained, that is, the entropic physical flow from nature’s sources through the economy and back to nature’s sinks, is to be nondeclining. More exactly, the capacity of the ecosystem to

sustain those flows is not to be run down. Natural capital is to be kept intact.<sup>2</sup> The future will be at least well off as the present in terms of its access to biophysical resources and services supplied by the ecosystem. Throughput here refers to total throughput flow for the community over some time period (i.e., the product of per capita throughput and population).

These are two totally different concepts of sustainability. Utility is a basic concept in standard economics. Throughput is not, in spite of the efforts of Kenneth Boulding and Nicholas Georgescu-Roegen to introduce it. So it is not surprising that the utility definition has been dominant. Natural capital is the capacity of the ecosystem to yield both a flow of natural resources and a flux of natural services. Keeping natural capital constant is often referred to as 'strong sustainability' in distinction to 'weak sustainability' in which the sum of natural and manmade capital is kept constant.

Nevertheless, I adopt the throughput definition and reject the utility definition, for two reasons. First, utility is non-measurable. Second, and more importantly, even if utility were measurable it is still not something that we can bequeath to the future. Utility is an experience, not a thing. We cannot bequeath utility or happiness to future generations. We can leave them things and, to a lesser degree, knowledge.<sup>3</sup> Whether future generations make themselves happy or miserable with these gifts is simply not under our control. To define sustainability as a non-declining intergenerational bequest of something that can neither be measured nor bequeathed strikes me as a nonstarter.<sup>4</sup> I hasten to add that I do not think economic theory can get along without the concept of utility. I just think that throughput is a better concept by which to define sustainability.

The throughput approach defines sustainability in terms of something much more measurable and transferable across generations—the capacity to generate an entropic throughput from and back to nature.<sup>5</sup> Moreover this throughput is the metabolic flow by which we live and produce. The economy in its physical dimensions is made up of things—populations of human bodies, livestock, machines, buildings, and artifacts. All these things are what physicists call 'dissipative structures' that are maintained against the forces of entropy by a throughput from the environment. An animal can only maintain its life and organizational structure by means of a metabolic flow through a digestive tract that connects to the environment at both ends. So too with all dissipative structures and their aggregate, the human economy.

Economists are very fond of the circular flow vision of the economy, inspired by the circulation of blood discovered by William Harvey (1628), emphasized by the Physiocrats, and reproduced in the first chapter of every economics textbook. Somehow the digestive tract has been less

inspirational to economists than the circulatory system. An animal with a circulatory system, but no digestive tract, could it exist, would be a perpetual motion machine. Biologists do not believe in perpetual motion. Economists seem dedicated to keeping an open mind on the subject.

Bringing the concept of throughput into the foundations of economic theory does not reduce economics to physics, but it does force the recognition of the constraints of physical law on economics. Among other things, it forces the recognition that ‘sustainable’ cannot mean ‘forever’.<sup>6</sup> Sustainability is a way of asserting the value of longevity and intergenerational justice, while recognizing mortality and finitude. Sustainable development is not a religion, although some seem to treat it as such. Since large parts of the throughput are nonrenewable resources the expected lifetime of our economy is much shorter than that of the universe. Sustainability in the sense of longevity requires increasing reliance on the renewable part of the throughput, and a willingness to share the nonrenewable part over many generations.<sup>7</sup> Of course longevity is no good unless life is enjoyable, so we must give the utility definition its due in providing a necessary baseline condition. That said, in what follows I adopt the throughput definition of sustainability, and will have nothing more to say about the utility definition.

Having defined ‘sustainable’ let us now tackle ‘development’. Development might more fruitfully be defined as more utility per unit of throughput, and growth defined as more throughput. But since current economic theory lacks the concept of throughput, we tend to define development simply as growth in GDP, a value index that conflates the effects of changes in throughput and utility.<sup>8</sup> The hope that the growth increment will go largely to the poor, or at least trickle down, is frequently expressed as a further condition of development. Yet any serious policy of redistribution of GDP from rich to poor is rejected as ‘class warfare’ that is likely to slow GDP growth. Furthermore, any recomposition of GDP from private goods toward public goods (available to all, including the poor) is usually rejected as government interference in the free market—even though it is well known that the free market will not produce public goods. We are assured that a rising tide lifts all boats that the benefits of growth will eventually trickle down to the poor. The key to development is still aggregate growth, and the key to aggregate growth is currently thought to be global economic integration—free trade and free capital mobility. Export-led development is considered the only option. Import substitution is no longer mentioned, except to be immediately dismissed as ‘discredited’.

Will this theory or ideology of “development as global growth” be successful? I doubt it, for two reasons, one having to do with environmental sustainability, the other with social equity:

- Ecological limits are rapidly converting economic growth into uneconomic growth—i.e., throughput growth that increases costs by more than it increases benefits, thus making us poorer not richer. The macroeconomy is not the Whole—it is Part of a larger Whole, namely the ecosystem. As the macroeconomy grows in its physical dimensions (throughput), it does not grow into the infinite Void. It grows into and encroaches upon the finite ecosystem, thereby incurring an opportunity cost of preempted natural capital and services. These opportunity costs (depletion, pollution, sacrificed ecosystem services) can be, and often are, worth more than the extra production benefits of the throughput growth that caused them. We cannot be absolutely sure because we measure only the benefits, not the costs.<sup>9</sup> We do measure the regrettable defensive expenditures made necessary by the costs, but even those are added to GDP rather than subtracted.
- Even if growth entailed no environmental costs, part of what we mean by poverty and welfare is a function of relative rather than absolute income, that is, of social conditions of distributive inequality. Growth cannot possibly increase everyone’s relative income. Insofar as poverty or welfare is a function of relative income, then growth becomes powerless to affect it.<sup>10</sup> This consideration is more relevant when the growth margin is devoted more to relative wants (as in rich countries) than when devoted more to absolute wants (as in poor countries). But if the policy for combating poverty is global growth then the futility and waste of growth dedicated to satisfying the relative wants of the rich cannot be ignored.

Am I saying that wealth has nothing to do with welfare, and that we should embrace poverty? Not at all! More wealth is surely better than less, up to a point. The issue is, does growth increase net wealth? How do we know that throughput growth, or even GDP growth, is not at the margin increasing ‘illth’ faster than wealth, making us poorer, not richer?<sup>11</sup> Illth accumulates as pollution at the output end of the throughput, and as depletion at the input end. Ignoring throughput in economic theory leads to treating depletion and pollution as ‘surprising’ external costs, if recognized at all. Building the throughput into economic theory as a basic concept allows us to see that illth is necessarily generated along with wealth. When a growing throughput generates illth faster than wealth then its growth has become uneconomic. Since macroeconomics lacks the concept of throughput it is

to be expected that the concept of ‘uneconomic growth’ will not make sense to macroeconomists.

While growth in rich countries might be uneconomic, growth in poor countries where GDP consists largely of food, clothing, and shelter, is still very likely to be economic. Food, clothing, and shelter are absolute needs, not self-canceling relative wants for which growth yields no welfare. There is much truth in this, even though poor countries too are quite capable of deluding themselves by counting natural capital consumption (depleting mines, wells, forests, fisheries, and topsoil) as if it were Hicksian income.<sup>12</sup> One might legitimately argue for limiting growth in wealthy countries (where it is becoming uneconomic) in order to concentrate resources on growth in poor countries (where it is still economic).

The current policy of the IMF, WTO and WB, however, is decidedly not for the rich to decrease their uneconomic growth to make room for the poor to increase their economic growth. The concept of uneconomic growth remains unrecognized. Rather the vision of globalization requires the rich to grow rapidly in order to provide markets in which the poor can sell their exports. It is thought that the only option poor countries have is to export to the rich, and to do that they have to accept foreign investment from corporations who know how to produce the high-quality stuff that the rich want. The resulting necessity of repaying these foreign loans reinforces the need to orient the economy towards exporting, and exposes the borrowing countries to the uncertainties of volatile international capital flows, exchange rate fluctuations, and unrepayable debts, as well as to the rigors of competing with powerful world-class firms.

The whole global economy must grow for this policy to work, because unless the rich countries grow rapidly they will not have the surplus to invest in poor countries, nor the extra income with which to buy the exports of the poor countries.

The inability of macroeconomists to conceive of uneconomic growth is very strange, given that microeconomics is about little else than finding the optimal extent of each micro activity. An optimum, by definition, is a point beyond which further growth is uneconomic. The cardinal rule of microeconomic optimization is to grow only to the point at which marginal cost equals marginal benefit. That has been aptly called the ‘when to stop’ rule—when to stop growing, that is. Macroeconomics has no ‘when to stop’ rule. GDP is supposed to grow forever.<sup>13</sup> The reason is that the growth of the macroeconomy is not thought to encroach on anything and thereby incur any growthlimiting opportunity cost. By contrast the microeconomic parts grow into the rest of the macroeconomy by competing away resources from other microeconomic activities thereby incurring an opportunity cost. The macroeconomy, however, is thought to grow into the

infinite Void, never encroaching on or displacing anything of value. The point to be emphasized is that the macroeconomy too is a Part of a larger finite Whole, namely the ecosystem. The optimal scale of the macroeconomy relative to its containing ecosystem is the critical issue to which macroeconomics has been blind. This blindness to the costs of growth in scale is largely a consequence of ignoring throughput, and has led to the problem of ecological unsustainability.

### **Growth by Global Integration: Comparative and Absolute Advantage and Related Confusions**

Under the current ideology of export-led growth the last thing poor countries are supposed to do is to produce anything for themselves. Any talk of import substitution is nowadays met by trotting out the abused and misunderstood doctrine of comparative advantage. The logic of comparative advantage is unassailable, given its premises. Unfortunately one of its premises (as emphasized by Ricardo) is capital immobility between nations. When capital is mobile, as indeed it is, we enter the world of absolute advantage, where, to be sure, there are still global gains from specialization and trade. However, there is no longer any guarantee that each country will necessarily benefit from free trade as under comparative advantage. One way out of this difficulty would be to greatly restrict international capital mobility thereby making the world safe for comparative advantage.<sup>14</sup> The other way out would be to introduce international redistribution of the global gains from trade resulting from absolute advantage. Theoretically the gains from absolute advantage specialization would be even greater than under comparative advantage because we would have removed a constraint to the capitalists' profit maximization, namely the international immobility of capital. But absolute advantage has the political disadvantage that there is no longer any guarantee that free trade will mutually benefit all nations. Which solution does the IMF advocate—comparative advantage vouchsafed by capital immobility, or absolute advantage with redistribution of gains to compensate losers? Neither. They prefer to pretend that there is no contradiction, and call for both comparative advantage-based free trade, and free international capital mobility—as if free capital mobility were a logical extension of comparative advantage-based free trade instead of a negation of its premise. This is incoherent.

In an economically integrated world, one with free trade and free capital mobility, and increasingly free, or at least uncontrolled, migration, it is difficult to separate growth for poor countries from growth for rich countries, since national boundaries become economically meaningless. Only by adopting a more nation-based approach to development can we say that growth should continue in some countries but not in others. But the globalizing trio, the IMF, WTO, and WB cannot say this. They can only advocate continual global growth in GDP. The concept of uneconomic growth just does not compute in their vision of the world. Nor does their cosmopolitan ideology recognize the nation as a fundamental unit of community and policy, even though their founding charter defines the IMF and World Bank as a federation of nations.

### **Ignoring Throughput in Macroeconomics: GDP and Value Added**

As noted, throughput and scale of the macroeconomy relative to the ecosystem are not familiar concepts in economics. Therefore let us return for a while to the familiar territory of GDP and value added, and approach the concept of throughput by this familiar path. Economists define GDP as the sum of all value added by labor and capital in the process of production.<sup>15</sup> Exactly what it is that value is being added to is a question to which little attention is given. Before considering it let us look at value added itself.

Value added is simultaneously created and distributed in the very process of production. Therefore, economists argue that there is no GDP ‘pie’ to be independently distributed according to ethical principles. As Kenneth Boulding put it, instead of a ‘pie’, there are only a lot of little ‘tarts’ consisting of the value added by different people or different countries, and mindlessly aggregated by statisticians into an abstract ‘pie’ that doesn’t really exist as an undivided totality. If one wants to redistribute this imaginary ‘pie’ one should appeal to the generosity of those who baked larger ‘tarts’ to share with those who baked smaller ‘tarts’, not to some invidious notion of equal participation in a fictitious common inheritance.

I have considerable sympathy with this view, as far as it goes. But it leaves out something very important.

In our one-eyed focus on value added we economists have neglected the correlative category, ‘that to which value is added’, namely the throughput. ‘Value added’ by labor and capital has to be added to something, and the quality and quantity of that something is important. There is a real and important sense in which the original contribution of nature is indeed a ‘pie’,

a pre-existing, systemic totality that we all share as an inheritance. It is not an aggregation of little tarts that we each baked ourselves. Rather it is the seed, soil, sunlight, and rain from which the wheat and apples grew that we converted into tarts by our labor and capital. The claim for equal access to nature's bequest is not the invidious coveting of what our neighbor produced by her own labor and abstinence. The focus of our demands for income to redistribute to the poor, therefore, should be on the value of the contribution of nature, the original value of the throughput to which further value is added by labor and capital—or, if you like, the value of low entropy added by natural processes to neutral, random, elemental stuff.

### **Ignoring Throughput in Microeconomics: The Production Function**

But there is also a flaw in our very understanding of production as a physical process. Neoclassical production functions are at least consistent with the national accountant's definition of GDP as the sum of value added by labor and capital, because they usually depict output as a function of only two inputs, labor and capital. In other words, value added by labor and capital in production is added to nothing, not even valueless neutral stuff. But value cannot be added to nothing. Neither can it be added to ashes, dust, rust, and the dissipated heat energy in the oceans and atmosphere. The lower the entropy of the input the more capable it is of receiving the imprint of value added by labor and capital. High entropy resists the addition of value. Since human action cannot produce low entropy in net terms we are entirely dependent on nature for this ultimate resource by which we live and produce (Georgescu-Roegen 1971). Any theory of production that ignores this fundamental dependence on throughput is bound to be seriously misleading.

As an example of how students are systematically misled on this issue I cite a textbook used in the microeconomic theory course at my institution. On p 146 the student is introduced to the concept of production as the conversion of inputs into outputs via a production function. The inputs or factors are listed as capital ( $K$ ), labor ( $L$ ), and materials ( $M$ )—the inclusion of materials is an unusual and promising feature (Perloff 2001). We turn the page to p.147 where we now find the production function written symbolically as  $q = f(K, L)$ .  $M$  has disappeared, never to be seen again in the rest of the book. Yet the output referred to in the text's 'real world example' of the production process is 'wrapped candy bars'. Where in the production function are the candy and wrapping paper as inputs?<sup>16</sup> Production func-



tions are often usefully described as technical recipes. But unlike real recipes in real cookbooks we are seldom given a list of ingredients!

And even when neoclassicals do include resources as a generic ingredient it is simply  $R$  raised to an exponent and multiplied by  $L$  and  $K$ , also each raised to an exponent. Such a multiplicative form means that  $R$  can approach zero if only  $K$  and  $L$  increase sufficiently. Presumably we could produce a 100-pound cake with only a pound of sugar, flour, eggs, etc., if only we had enough cooks stirring hard in big pans and baking in a big enough oven!

The problem is that the production process is not accurately described by the mathematics of multiplication. Nothing in the production process is analogous to multiplication.<sup>17</sup> What is going on is transformation, a fact that is hard to recognize if throughput is absent.  $R$  is that which is being transformed from raw material to finished product and waste (the latter symptomatically is not listed as an output in production functions).  $R$  is a flow.  $K$  and  $L$  are agents of transformation, stocks (or funds) that effect the transformation of input  $R$  into output  $Q$ , but which are not themselves physically embodied in  $Q$ . There can be substitution between  $K$  and  $L$ , both agents of transformation, and there can be substitution among parts of  $R$  (aluminum for copper), both things undergoing transformation. But the relation between agent of transformation (efficient cause) and the material undergoing transformation (material cause), is fundamentally one of complementarity. Efficient cause is far more a complement than a substitute for material cause! This kind of substitution is limited to using a little extra labor or capital to reduce waste of materials in process—a small margin soon exhausted.<sup>18</sup>

Language misleads us into thinking of the production process as multiplicative, since we habitually speak of output as ‘product’ and of inputs as ‘factors’. What could be more natural than to think that we multiply the factors to get the product! That, however, is mathematics, not production! If we recognized the concept of throughput we would speak of ‘transformation functions’, not production functions.

### **Opposite Problems: Non-Enclosure of the Scarce and Enclosure of the Non-Scarce**

Economists have traditionally considered nature to be infinite relative to the economy, and consequently not scarce, and therefore properly priced at zero. But nature is scarce, and becoming more so every day as a result of

throughput growth. Efficiency demands that nature's services be priced, as even Soviet central planners eventually discovered. But to whom should this price be paid? From the point of view of efficiency it does not matter who receives the price, as long as it is charged to the users. But from the point of view of equity it matters a great deal who receives the price for nature's increasingly scarce services. Such payment is the ideal source of funds with which to fight poverty and finance public goods.

Value added belongs to whoever added it. But the original value of that to which further value is added by labor and capital should belong to everyone. Scarcity rents to natural services, nature's value added, should be the focus of redistributive efforts. Rent is by definition a payment in excess of necessary supply price, and from the point of view of market efficiency is the least distorting source of public revenue.

Appeals to the generosity of those who have added much value by their labor and capital are more legitimate as private charity than as a foundation for fairness in public policy. Taxation of value added by labor and capital is certainly legitimate. But it is both more legitimate and less necessary after we have, as much as possible, captured natural resource rents for public revenue.

The above reasoning reflects the basic insight of Henry George, extending it from land to natural resources in general. Neoclassical economists have greatly obfuscated this simple insight by their refusal to recognize the productive contribution of nature in providing 'that to which value is added'. In their defense it could be argued that this was so because in the past economists considered nature to be non-scarce, but now they are beginning to reckon the scarcity of nature and enclose it in the market. Let us be glad of this, and encourage it further.

Although the main problem I am discussing is the non-enclosure of the scarce, an opposite problem (enclosure of the non-scarce) should also be noted. There are some goods that are by nature non-scarce and non-rival, and should be freed from illegitimate enclosure by the price system. I refer especially to knowledge. Knowledge, unlike throughput, is not divided in the sharing, but multiplied. There is no opportunity cost to me from sharing knowledge with you. Yes, I would lose the monopoly on my knowledge by sharing it, but we economists have long argued that monopoly is a bad thing because it creates artificial scarcity that is both inefficient and unjust. Once knowledge exists, the opportunity cost of sharing it is zero and its allocative price should be zero. Consequently, I would urge that international development aid should more and more take the form of freely and actively shared knowledge, and less and less the form of interest-bearing loans. Sharing knowledge costs little, does not create unrepayable

debts, and it increases the productivity of the truly scarce factors of production.

Although the proper allocative price of existing knowledge is zero, the cost of production of new knowledge is often greater than zero, sometimes much greater. This of course is the usual justification for intellectual property rights in the form of patent monopolies. Yet the main input to the production of new knowledge is existing knowledge, and keeping the latter artificially expensive will certainly slow down production of the former. This is an area needing much reconsideration. I only mention it here, and signal my skepticism of the usual arguments for patent monopolies, so emphasized recently by the free-trading globalizers under the gratuitous rubric of 'traderelated intellectual property rights'. As far as I know, James Watson and Francis Crick receive no patent royalties for having unraveled the structure of DNA, arguably the most basic scientific discovery of the twentieth century. Yet people who are tweaking that monumental discovery are getting rich from monopolizing their relatively trivial contributions that could never have been made without the free knowledge supplied by Watson and Crick.

Although the main thrust of my remarks is to bring newly scarce and truly rival natural capital and services into the market enclosure, we should not overlook the opposite problem, namely, freeing truly non-rival goods from their artificial enclosure by the market.

## **Principles and Policies for Sustainable Development**

I am not advocating revolutionary expropriation of all private property in land and resources. If we could start from a blank slate I would be tempted to keep land and minerals as public property. But for many environmental goods, previously free but increasingly scarce, we still do have a blank slate as far as ownership is concerned. We must bring increasingly scarce yet unowned environmental services under the discipline of the price system, because these are truly rival goods the use of which by one person imposes opportunity costs on others.<sup>19</sup> But for efficiency it matters only that a price be charged for the resource, not who gets the price. The necessary price or scarcity rent that we collect on newly scarce environmental public goods (e.g., atmospheric absorption capacity, the electromagnetic spectrum) should be used to alleviate poverty and finance the provision of other public goods.

The modern form of the Georgist insight is to tax the resources and services of nature (those scarce things left out of both the production function

and GDP accounts)—and to use these funds for fighting poverty and for financing public goods. Or we could simply disburse to the general public the earnings from a trust fund created by these rents, as in the Alaska Permanent Fund, which is perhaps the best existing institutionalization of the Georgist principle. Taking away by taxation the value added by individuals from applying their own labor and capital creates resentment. Taxing away value that no one added, scarcity rents on nature's contribution, does not create resentment. In fact, failing to tax away the scarcity rents to nature and letting them accrue as unearned income to favored individuals has long been a primary source of resentment and social conflict.

Charging scarcity rents on the throughput of natural resources and redistributing these rents to public uses can be effected either by ecological tax reform (shifting the tax base away from value added and on to throughput), or by quantitative cap-and-trade systems initiated by a government auction of pollution or depletion quotas. In differing ways each would limit throughput and expansion of the scale of the economy into the ecosystem, and also provide public revenue. I will not discuss their relative merits, having to do with price versus quantity interventions in the market, but rather emphasize the advantage that both have over the currently favored strategy. The currently favored strategy might be called 'efficiency first' in distinction to the 'frugality first' principle embodied in both of the throughput-limiting mechanisms mentioned above.<sup>20</sup>

'Efficiency first' sounds good, especially when referred to as 'win-win' strategies or more picturesquely as 'picking the low-hanging fruit'. But the problem of 'efficiency first' is with what comes second. An improvement in efficiency by itself is equivalent to having a larger supply of the factor whose efficiency increased. The price of that factor will decline. More uses for the now cheaper factor will be found. We will end up consuming more of the resource than before, albeit more efficiently. Scale continues to grow. This is sometimes called the 'Jevons effect'. A policy of 'frugality first', however, induces efficiency as a secondary consequence; 'efficiency first' does not induce frugality—it makes frugality less necessary, nor does it give rise to a scarcity rent that can be captured and redistributed.

I am afraid I will be told by some of my neoclassical colleagues that frugality is a value-laden concept, especially if you connect it with redistribution of scarcity rents to the poor. Who am I, they will ask, to impose my personal elitist preferences on the democratic marketplace, blah, blah, etc. etc. I am sure everyone has heard that speech. The answer to such sophistry is that ecological sustainability and social justice are fundamental objective values, not subjective individual preferences. There really is a difference, and it is past time for economists to recognize it.

## **Conclusion**

Reducing poverty is indeed the basic goal of development, as the World Bank now commendably proclaims. But it cannot be attained by growth for two reasons. First, because growth in GDP has begun to increase environmental and social costs faster than it increases production benefits. Such uneconomic growth makes us poorer, not richer. Second, because even truly economic growth cannot increase welfare once we are, at the margin, producing goods and services that satisfy mainly relative rather than absolute wants. If welfare is mainly a function of relative income then aggregate growth is selfcanceling in its effect on welfare. The obvious solution of restraining uneconomic growth for rich countries to give opportunity for further economic growth, at least temporarily, in poor countries, is ruled out by the ideology of globalization, which can only advocate global growth. We need to promote national and international policies that charge adequately for resource rents, in order to limit the scale of the macroeconomy relative to the ecosystem and to provide a revenue for public purposes. These policies must be grounded in an economic theory that includes throughput among its most basic concepts. These efficient national policies need protection from the cost-externalizing, standardslowering competition that is driving globalization. Protecting efficient national policies is not the same as protecting inefficient national industries.

## **Endnotes**

- <sup>1</sup> This chapter is a revised version of the invited address “Sustainable Development: Definitions, Principles, Policies” at the World Bank, April 30, 2002, Washington DC
- <sup>2</sup> Natural capital is the capacity of the ecosystem to yield both a flow of natural resources and a flux of natural services.
- <sup>3</sup> To a lesser degree because knowledge must be actively learned anew each generation. It cannot simply be passively inherited.
- <sup>4</sup> It also puts the future at a disadvantage—the present could bequeath an ever smaller throughput, and claim that this is sufficient for non declining utility if only the future takes full advantage of foreseeable possibilities of substitution in both production and utility functions. But if these substitution possibilities are so easy to foresee, then let the present take advantage of them now and thereby reduce its utility cost of a given throughput bequest.
- <sup>5</sup> The throughput is not only measurable in principle but has been measured for several industrial countries in the pioneering physical accounting studies

published by WRI in collaboration with Dutch, German, Japanese, and Austrian research institutes. See Adriaanse et al. (1997), and Matthews et al. (2000).

- <sup>6</sup> Science tells us the physical world will end either in the big cooling or the big crunch. 'Forever' requires a 'new creation'—death and rebirth, not perpetual extension. Economics is not eschatology.
- <sup>7</sup> Investing non-renewable resource rents in renewable substitutes is a good policy, with impeccable neoclassical roots, for sustaining the throughput over a longer time.
- <sup>8</sup> The prices used in calculating this value index are of course affected by the distributions of wealth and income, as well as by the exclusion of the demand of future generations and non human species, and by the failure to have included other external costs and benefits into prices. It is hard to give a normative meaning to an index constructed with such distorted relative prices.
- <sup>9</sup> Evidence that growth in the US since the 1970s has likely been uneconomic is presented in Daly and Cobb (1994) appendix on the Index of Sustainable Economic Welfare.
- <sup>10</sup> If welfare is a function of relative income, and growth increases everyone's income proportionally, then no one is better off. If growth increases only some incomes, then the welfare gains of the relatively better off are cancelled by the losses of the relatively worse off.
- <sup>11</sup> 'Illth' is John Ruskin's useful term for the opposite of wealth, i.e., an accumulated stock of bads as opposed to a stock of goods.
- <sup>12</sup> Instead of 'deluding themselves' perhaps I should say 'being deluded' by IMF and World Bank economists who require this misleading system of national accounts of them.
- <sup>13</sup> Macroeconomists do recognize that the economy can grow too fast when it causes inflation, even though the economy can never be too big in their view.
- <sup>14</sup> How might capital flows be restricted? A Tobin tax; a minimum residence time before foreign investment could be repatriated; and most of all something like Keynes' International Clearing Union in which multilateral balance on trade account is encouraged by charging interest on both surplus and deficit balances on current account. To the extent that current accounts are balanced, then capital mobility is correspondingly restricted.
- <sup>15</sup> Note that GDP does not value resources (that to which value is added). Yet we all pay a price in the market for gasoline. That gasoline price, however, reflects the labor and capital expended in drilling, pumping, and refining the petroleum, not the value of petroleum *in situ*, which is taken as zero. Your uncle in Texas discovered oil on his ranch and Texaco is paying him for the right to extract it. Is that not a positive price for petroleum *in situ*? It looks like it, but the amount Texaco will pay your uncle is determined by how easy it is to extract his oil relative to marginal deposits. Thus it is labor and capital saved in extraction that determines the rent to your uncle, not the value of oil *in situ* itself, which is still counted as zero.
- <sup>16</sup> Some readers may rush to the defense of the textbook and tell me that the production function is only describing value added by *L* and *K* and that is why they

omitted material inputs. Let me remind such readers that on the previous page they included material inputs, and further that the production function is in units of physical quantities, not values or value added. Even if expressed in aggregate units of ‘dollar’s worth’, it remains the case that a ‘dollar’s worth’ of something is a physical quantity.

- <sup>17</sup> I should say that I am thinking of the unit process of production—one laborer with one saw and one hammer converts lumber and nails into one doghouse in one period of time. We could of course multiply the unit process by ten and get ten doghouses made by ten laborers, etc. My point is that the unit process of production, which is what the production function describes, involves no multiplication.
- <sup>18</sup> Of course one might imagine entirely novel technologies that use totally different resources to provide the same service. This would be a different production function, not substitution of factors within a production function. And if one wants to induce the discovery of new production functions that use the resource base more efficiently, then it would be a good idea to count resources as a factor of production in the first place, and to see to it that adequate prices are charged for their use! Otherwise such new technologies will not be profitable.
- <sup>19</sup> For example, rents can be collected on atmospheric sink capacity, electromagnetic broadcast spectrum, fisheries, public timber and pasture lands, offshore oil, rights of way, orbits, etc.
- <sup>20</sup> By ‘frugality’ I mean ‘non-wasteful sufficiency’, rather than ‘meager scantiness’.

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