

Stone Lecture 2010

"National Wealth and Sustainable Development"

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What Should be Sustained?

The famous Brundtland Commission Report defined sustainable development as "... development that meets the needs of the present without compromising the ability of future generations to meet their own needs."

Deficiencies in the "Brundtland" Notion

(1) It makes no mention of human well-being.

(2) It makes relatively weak demands on intergenerational justice. In the Commission's view, sustainable development requires that future generations have no less of the means to meet their needs than we do ourselves; it requires nothing more. As needs are the austere component of well-being, economic development could be sustainable in the Commission's sense without having much to show for it.

(3) The Commission's definition is directed at sustaining the factors that determine needs. In that view "sustainable development" requires that relative to their populations, each generation should bequeath to its successor at least as large a quantity of what may be called an economy's "productive base" as it had itself inherited from its predecessor. The problem is that it doesn't explain how the productive base should be measured.

Proposed Definition

Definition 1: An economy follows a sustainable development path over a period of time if intergenerational well-being does not decline in that period.

The problem with Definition 1 is that, as intergenerational well-being is a non-linear function of the flow of consumption over time it is hard to put it to empirical work. We need an index that (a) is linear in the quantities of goods and services, and (b) moves in the same way over time as intergenerational well-being. If such an index were found, it could be used as a surrogate for intergenerational well-being in our Definition.

The index we seek is that of an economy's productive base. An economy's productive base consists of the full range of capital assets to which it has access: reproducible capital (roads, buildings, machinery and equipments), human capital (health, education, skills), population (size and demographic profile), public knowledge (science and technology), natural capital, and the myriad of formal and informal institutions (e.g., the rule of law, social norms and conventions) that guide the allocation of resources.

It transpires that reproducible capital, human capital, and natural capital enter quantitative estimates of sustainable development in a somewhat different way from population, public knowledge, and institutions.

Definition 2: An asset's shadow price is the contribution a further unit of it would make to intergenerational well-being, other things being equal.

Definition 3: An economy's (comprehensive) wealth is the shadow value of all its capital assets. Formally, if $P_i(t)$ is the shadow price of asset i and $K_i(t)$ is the total quantity of i at t , then

$$W(t) = \sum_i [P_i(t)K_i(t)],$$

where $W(t)$ is (comprehensive) wealth.

Proposition 1: At any moment t , intergenerational well-being increases (resp. decreases) if and only if, holding shadow prices constant, (comprehensive) wealth increases (resp. decreases).

Proposition 2 (follows directly from Proposition 1): At any moment t , intergenerational well-being increases (resp. decreases) if and only if (comprehensive) investment evaluated at shadow prices is positive (resp. negative).

Table 1**INDIA**

	Natural						Forest			
	Oil	Gas	Bauxite	Iron	Gold	Lead	Timber	Benefits	Land	TOTAL Natural Capital
Capital Stock 1995	8.17	1.09	2.33	4.13	0.00	0.00	1.805	0.066		
Capital Stock 2000	6.73	0.97	2.30	3.90	0.00	0.00	1.865	0.068		2,121.83
Change in Stock	-1.44	-0.12	-0.03	-0.23	0.00	0.00	0.060	0.002		
Average Price	20.21	102	25	46	10.9m	823	35			
Extraction Cost	14.18	54	12	13	10.7m	696	27			
Accounting Price	6.03	48.07	13	33	.207m	126	9	2,432		
1995 Stock Value	49.23	52.40	30.91	136.6	0.01	0.32	15.42	159.89	1694.56	2139.38
Value of Change	-8.66	-5.82	-0.40	-7.57	0.00	-0.02	0.51	4.40		-17.56

Table 2**INDIA**

	Natural Capital	Human Capital	Reproducible Capital	Oil Net Capital Gains	Carbon Damages	TOTAL
1995 Capital Stock	2,139.38	5,983.36	1,429.82			9,552.560
2000 Capital Stock	2,121.83	6,934.61	2,035.00			10,861.898
Change 1995-2000	-17.56	951.25	605.18	-141.50	-88.042	1,309.338
Percentage Change	-0.82%	15.90%	42.33%			13.71%
Growth Rate	-0.16%	2.99%	7.31%			2.60%

**Table 3: Growth Rates (in Percent) of Per-Capita Comprehensive Wealth,
Adjusted for Technological Change**

	(1) Comprehensive Wealth Growth Rate	(2) Population Growth Rate	(3) Per Capita Comprehensive Wealth Growth Rate, Accounting for Population Growth [(1) - (2)]	(4) TFP Growth Rate	(5) Per Capita Comprehensive Wealth Growth Rate, Accounting for TFP Growth [(3) + (4)]	(6) Per Capita GDP Growth Rate
US	1.39	1.17	0.22	1.48	1.70	2.93
CHINA	3.86	0.94	2.92	2.71	5.63	7.60
BRAZIL	1.49	1.50	-0.01	0.15	0.14	0.50
INDIA	2.60	1.74	0.86	1.84	2.70	3.99
VENEZUELA	1.15	1.98	-0.79	-2.12	-2.94	-1.20

Table 4: Per Capita Health Capital and Valuation

	United States	China	Brazil	India	Venezuela
Per-Capita Health Capital					
2000	16.067	16.408	16.513	16.165	17.131
2005	16.212	16.495	16.738	16.285	17.235
Change	0.145	0.087	0.225	0.121	0.104
Percentage change	0.90%	0.53%	1.36%	0.75%	0.61%
VSLY	\$392,109	\$104,268	\$148,187	\$77,904	\$125,402
VSL					
2000	\$6,300,000	\$1,710,857	\$2,447,023	\$1,259,319	\$2,148,269
2005	\$6,356,761	\$1,719,892	\$2,480,400	\$1,268,710	\$2,161,281
Change	\$56,761	\$9,035	\$33,377	\$9,391	\$13,012

Table 5: Per Capita Components of Comprehensive Investment Including Health
(in 2000 US dollars)

UNITED STATES (per capita)

	Natural Capital	Human Capital	Reproducible Capital	Health Capital	Oil Net Capital Gains	Carbon Damages	TOTAL
1995 Capital Stock	\$21,386	\$225,655	\$50,438	\$6,300,000			\$6,597,480
2000 Capital Stock	\$20,205	\$229,614	\$56,423	\$6,356,761			\$6,657,550
Change 1995-2000	-\$1,181	\$3,959	\$5,984	\$56,761	-\$4,845	-\$608	\$60,071
Percentage Change	-5.52%	1.75%	11.86%	0.90%			0.91%
Growth Rate	-1.13%	0.35%	2.27%	0.18%			0.18%

CHINA (per capita)

	Natural Capital	Human Capital	Reproducible Capital	Health Capital	Oil Net Capital Gains	Carbon Damages	TOTAL
1995 Capital Stock	\$3,199	\$7,049	\$3,076	\$1,710,857			\$1,724,181
2000 Capital Stock	\$3,047	\$7,440	\$5,126	\$1,719,892			\$1,735,256
Change 1995-2000	-\$152	\$392	\$2,049	\$9,035	-\$242	-\$7	\$11,075
Percentage Change	-4.75%	5.55%	66.62%	0.53%			0.64%
Growth Rate	-0.97%	1.09%	10.75%	0.11%			0.13%

BRAZIL (per capita)

	Natural Capital	Human Capital	Reproducible Capital	Health Capital	Oil Net Capital Gains	Carbon Damages	TOTAL
1995 Capital Stock	\$16,659	\$44,355	\$10,713	\$2,447,023			\$2,518,750
2000 Capital Stock	\$15,066	\$47,443	\$10,105	\$2,480,400			\$2,552,086
Change 1995-2000	-\$1,593	\$3,088	-\$607	\$33,377	-\$685	-\$245	\$33,336
Percentage Change	-9.56%	6.96%	-5.67%	1.36%			1.32%
Growth Rate	-1.99%	1.36%	-1.16%	0.27%			0.26%

INDIA (per capita)

	Natural Capital	Human Capital	Reproducible Capital	Health Capital	Oil Net Capital Gains	Carbon Damages	TOTAL
1995 Capital Stock	\$2,295	\$6,419	\$1,534	\$1,259,319			\$1,269,567
2000 Capital Stock	\$2,276	\$7,439	\$2,183	\$1,268,710			\$1,280,382
Change 1995-2000	-\$19	\$1,020	\$649	\$9,391	-\$139	-\$87	\$10,816
Percentage Change	-0.82%	15.90%	42.33%	0.75%			0.85%
Growth Rate	-0.16%	2.99%	7.31%	0.15%			0.17%

VENEZUELA (per capita)

	Natural Capital	Human Capital	Reproducible Capital	Health Capital	Oil Net Capital Gains	Carbon Damages	TOTAL
1995 Capital Stock	\$163,589	\$23,890	\$9,128	\$2,148,269			\$2,344,876
2000 Capital Stock	\$143,789	\$24,171	\$8,420	\$2,161,281			\$2,350,433
Change 1995-2000	-\$19,800	\$281	-\$708	\$13,012	\$13,247	-\$475	\$5,557
Percentage Change	-12.10%	1.18%	-7.75%	0.61%			0.24%
Growth Rate	-2.55%	0.23%	-1.60%	0.12%			0.05%

Table 6: Sensitivity Analysis

Growth Rates (in percent) of Per-Capita Comprehensive Wealth under Alternative Assumptions

A: Social Cost of Carbon

	United States	China	Brazil	India	Venezuela
\$50/ton cost of carbon	1.70	5.63	0.14	2.70	-2.91
\$100/ton cost of carbon	1.66	5.62	0.07	2.54	-2.96
\$500/ton cost of carbon	1.33	5.54	-0.49	1.16	-3.37

Per-capita comprehensive wealth growth rates include technological change but exclude health

B: Inclusion / Exclusion of Health Capital

	United States	China	Brazil	India	Venezuela
Health Capital Excluded					
No TFP Adjustment	0.22	2.92	-0.01	0.86	-0.79
TFP Adjustment	1.70	5.63	0.14	2.70	-2.94
Health Capital Included					
No TFP Adjustment	0.18	0.13	0.26	0.17	0.05
TFP Adjustment	1.66	2.84	0.41	2.01	-2.07

C: Discount Rate Applied to Additional Years of Life

	United States	China	Brazil	India	Venezuela
Low discounting (0.03)	1.72	2.88	0.53	2.06	-2.01
Base Case (0.05)	1.66	2.84	0.41	2.01	-2.07
High discounting (0.07)	1.62	2.81	0.34	1.98	-2.11

Per-capita comprehensive wealth growth rates in this panel include technological change and health

D: Value of a Statistical Life

	United States	China	Brazil	India	Venezuela
VSL proportional to the 0.6 power of GDP	1.66	2.84	0.41	2.01	-2.07
VSL proportional to GDP	1.66	2.87	0.40	2.03	-2.14
VSL the same for all countries (\$6.3 million)	1.66	2.82	0.42	1.99	-2.03
VSL the same for all countries (\$1.0 million)	1.67	2.85	0.40	2.02	-2.14

Per-capita comprehensive wealth growth rates in this panel include technological change and health

Conclusions from Empirical Exercise on 5 Countries

(2000-2005)

1. The (shadow) value of human capital in the form of health is more than twice as large as all other forms of capital combined.
2. However, growth in health capital did not, in the period in question, swamp growth in other forms of capital assets.

Conclusions from Empirical Exercise on 5 Countries: contd.

(2000-2005)

3. US, China, and India met the sustainability criterion.
4. Brazil did so only narrowly.
5. Venezuela did not meet the criterion.