Accounting for Sustainable Development

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The meaning of the English word “sustain”

1. to keep in existence, maintain
2. to provide for the support of
3. to support from below
4. to strengthen the spirits, courage
5. to bear up against, endure, withstand
6. to undergo or suffer loss etc
7. to uphold the validity or justice
8. to confirm, corroborate

Sustainable development

Sustainable development is

... development that meets the needs of the present without compromising the ability of the future to meet their own need.

(Our Common Future, 1987)

Interpretation

Sustainable development is development that maintains or sustains social welfare

What is social welfare?

- An individual's wellbeing in one period is determined by
  - consumption
    - ordinary consumption
    - amenities
    - health
- a measure of this concept of wellbeing is called utility
- Social welfare (W) = present value of the future stream of utility

Social welfare

$$W_0 = U(C^0) + \frac{U(C^1)}{(1+\delta)} + \frac{U(C^2)}{(1+\delta)^2} + \ldots$$

C^0 consumption in year 0, the first period,
C^1 consumption in year 1, etc
δ utility discount rate

Ramsay equation

$$r = \delta + g\eta$$

r consumption discount rate

δ utility discount rate

g consumption growth rate

η elasticity of the marginal utility of consumption

Sustainable development

Social welfare must not decrease over time

$$W_{t+1} - W_t \geq 0$$

for all t = 0, 1, 2, …

What determines the social welfare?

- Stocks of assets
  - man made capital stocks – buildings, machines, infrastructure
  - man made knowledge, that is, human capital
  - natural capital
- Technology
  - human capital
- Institutions
  - rules of the game

Resource allocation mechanism

Prediction of future consumption through resourace allocation mechanisms

$$C^t = \alpha_C(K^0_1, K^0_2, \ldots, K^0_n, t)$$

$$K^t = \alpha_K((K^0_1, K^0_2, \ldots, K^0_n, t)$$

The Value Function

$$W^t = \sum_{s=t}^{\infty} \frac{U(C^s)}{(1+\delta)^{s-t}} =$$

$$= \sum_{s=t}^{\infty} \frac{U(\alpha(K_1^t, K_2^t, \ldots, K_n^t, t))}{(1+\delta)^{s-t}} =$$

$$= V(K_1^t, K_2^t, \ldots, K_n^t, t)$$

Sustainable development

- Productive resources must be given to future generations in such amounts that their social welfare is not less than ours
- Thus, total investment in all assets (genuine investment) must be positive
- If investment is negative in some sectors, it must be sufficiently positive in others to guarantee that genuine investment is positive

Accounting prices

1. How do we aggregate changes in the stock of salmon, stock of vehicles, stock of buildings?

   By using accounting prices as weights!

2. The accounting price is the change in the social welfare from a marginal change in the stock today
3. The accounting price may be equal to or may differ from the corresponding market price
4. There is a huge literature on estimating accounting prices

Accounting price

$$p_i^t = \frac{\partial W^t}{\partial K^t_i}$$

Sustainable development

$$W^{t+1} - W^{t} = \sum_{i=1}^{n} p_i^{\,t} (K_i^{\,t+1} - K_i^{\,t}) + v_t$$

$$\sum_{i=1}^{n} p_i^{\,t} (K_i^{\,t+1} - K_i^{\,t}) : Genuine\ investment\ (World\ \ Bank)$$

$$v_t : Drift\ Term\ (Dasgupta, Mäler)$$

Population Change

Social Welfare Function

$$W^{t} = \frac{\sum_{s=t}^{\infty} \frac{U\left(\frac{C}{N_s}^{s}\right)}{(1+\delta)^{s-t}}}{\sum_{s=t}^{\infty} \frac{N_s}{(1+\delta)^{s-t}}}$$

Population changes

If exogenous population growth rate is constant, and

if there is constant return to scale,

then, the value function will be a function of capital per capita, and the sustainability criteria becomes:

$$W^{t+1} - W^{t} = \sum_{i=1}^{n} p_i^{\,t} \left(k_i^{\,t+1} - k_i^{\,t}\right) + v_t$$

Table 1: Genuine Investment and Components as Percentage of GDP

			Natural resource depletion				
Country	Domestic Net Investment	Education Expenditure	Damage from CO_2 emissions	Energy depletion	Mineral depletion	Net forest depletion	Genuine investment
Bangladesh 1973-2001	7.89	1.53	0.25	0.61	0.00	1.41	7.14
India 1970-2001	11.74	3.29	1.17	2.89	0.46	1.05	9.47
Nepal 1970-2001	14.82	2.65	0.20	0.00	0.30	3.67	13.31
Pakistan 1970-2001	10.92	2.02	0.75	2.60	0.00	0.84	8.75
China 1982-2001	30.06	1.96	2.48	6.11	0.50	0.22	22.72
SubSaharan Africa 1974-82; 1986-2001	3.49	4.78	0.81	7.31	1.71	0.52	-2.09
Middle East & North Africa 1976-89; 1991-2001	14.72	4.70	0.80	25.54	0.12	0.06	-7.00
United Kingdom 1971-2001	3.70	5.21	0.32	1.20	0.00	0.00	7.38
United States 1970-2001	5.73	5.62	0.42	1.95	0.05	0.00	8.94

Table 2: Growth Rates of Per-Capita Genuine Wealth

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Country	Genuine Investment as Percent of GDP	Growth Rate of Unadjusted Genuine Wealth	Population Growth Rate	Growth Rate of Per-Capita Genuine Wealth -before TFP Adjustment	TFP Growth Rate	Growth Rate of Per-Capita Genuine Wealth -after TFP Adjustment	Growth Rate of Per-Capita GDP
Bangladesh	7.14	1.07	2.16	-1.09	0.81	0.30	1.88
India	9.47	1.42	1.99	-0.57	0.64	0.54	2.96
Nepal	13.31	2.00	2.24	-0.24	0.51	0.63	1.86
Pakistan	8.75	1.31	2.66	-1.35	1.13	0.59	2.21
China	22.72	3.41	1.35	2.06	3.64	8.33	7.77
Sub-Saharan Africa	-2.09	-0.31	2.74	-3.05	0.28	-2.58	-0.01
Middle East and N. Africa	-7.09	-1.06	2.37	-3.43	-0.23	-3.82	0.74
United Kingdom	7.38	1.48	0.18	1.30	0.58	2.29	2.19
United States	8.94	1.79	1.07	0.72	0.02	0.75	1.99

Accounting for climate
A simple climate model

$$\frac{dK_\tau}{d\tau} = f(K_\tau, E_\tau, N_\tau) - C_\tau$$

$$U_\tau = N_\tau \varphi\left(\frac{C_\tau}{N_\tau}, T_\tau\right)$$

$$W_t = \frac{\sum_{\tau=t}^{\infty} \frac{N_\tau \varphi\left(\frac{C_\tau}{N_\tau}, T_\tau\right)}{(1+\delta)^{\delta(\tau-t)}}}{\sum_{\tau=t}^{\infty} \frac{N_\tau}{(1+\delta)^{\tau-t}}}$$

Accounting price for climate

$$\frac{\partial W_t}{\partial Q_t} = \frac{\sum_{\tau=t}^{\infty}\left[N_\tau \frac{\frac{\partial U}{\partial C_\tau}\frac{\partial C_\tau}{\partial Q_t} + \frac{\partial U}{\partial T_\tau}\frac{\partial T_\tau}{\partial Q_t}}{(1+\delta)^{\tau-t}}\right]}{\sum_{\tau=t}^{\infty}\frac{N_\tau}{(1+\delta)^{\tau-t}}}$$

$$MD_\tau = \frac{\partial U}{\partial C_\tau}\frac{\partial C_\tau}{\partial Q_t} + \frac{\partial U}{\partial T_\tau}\frac{\partial T_\tau}{\partial Q_t}$$

$$dQ_t = E_t - vQ_t$$

Accounting price for climate

- The accounting price for the stock of green house gases equals the marginal damage from emissions!
- There are a bewildering number of different estimates of this marginal damage
- They vary from almost zero to over hundred dollars per ton CO_2
- Stern review suggest $ 20, but later Stern has suggested $ 40 dollars per ton

Accounting price for climate – several countries

- Whose welfare?
  - our own country or all countries
- Effects from all countries or only our own country?
- Most reasonable:
  - our own welfare and effects from total emissions!
- Thus, component of genuine investment equals

$$p_t dQ_t^{tot}$$

A final example

- Botswana and Namibia similar:
  - Both very dry countries – water is very valuable
  - Both have diamonds
  - Botswana has cattle, and tourism
  - Namibia has forests, fisheries, and tourism
- Both have similar development of GDP per capita

A final example

- Wealth per capita has been going up in Botswana but going down in Namibia
- Why?
- Botswana has a legislation that requires that rent on natural capital **must** be reinvested in other forms of capital!
  - human capital – education
  - investment in small enterprises
- In Namibia, the rent on natural capital has been consumed!
  - partly through expenditures for having an army in Congo

Final conclusion

Wealth matters more than income!

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