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Measuring What Matters:
Challenges and Opportunities for Comprehensive National Accounting

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"If you are thinking of lending money to a company, you would not just ask for the income statement, but you would also ask for the balance sheet to understand whether the company's income is sustainable into the future. Why is it that we do not do that at the national accounting level?"

Joseph Stiglitz

Choosing the Appropriate Indicator

what to measures depends on the chosen definition of sustainable development

1. *current* well-being should be sustained

$$\Delta U(t) \geq 0 \iff \sum_{i=1}^{m} p_i(t)\Delta c_i(t) \geq 0$$

2. *intergenerational* well-being should be sustained

$$V(t) = \int_t^{\infty} U(t)e^{-\delta(s-t)}dt \rightarrow \quad \Delta V(t) \geq 0 \iff \sum_{i}^{n} q_i(t)\Delta K_i(t) \geq 0$$

Comprehensive Capital

1. **Reproducible Capital**: roads, buildings, ports, machinery, equipment
2. **Human Capital**: education, skills, physical and mental health
3. **Knowledge**: science and technology
4. **Natural Capital**: ecosystems, biomes, sub-soil resources
5. **Population**: size, demographic profile
6. **Institutions**: religious, social, and cultural capital
7. **Time!**

Shadow Price of Capital

The shadow price of a capital asset is the contribution a marginal unit of it is forecast to make to intergenerational well-being.

$$q_i(t) \equiv \frac{\partial V(t)}{\partial K_i(t)}$$

1. conveys information about the usefulness of the asset in the future
2. reflects social evaluation of intergenerational well-being
3. it is generally different from the market price because of externalities

Comprehensive Wealth and Sustainability

An economy's comprehensive wealth is the shadow value of all its capital assets:

$$W(t) = r(t)t + \sum_{i=1}^{n} q_i(t)K_i(t)$$

Theorem (Arrow et. al. 2012): Intergenerational well-being is sustainable at time t if and only if, holding shadow prices constant, comprehensive wealth weakly increases.

$$\Delta V(t)/\Delta t \geq 0 \iff \sum_{i=1}^{n} q_i(t)\Delta K_i(t)/\Delta t \geq 0$$

Comprehensive Wealth and Sustainability

Table 2. *Components of comprehensive investment (in 2000 US$ billions)*

	Natural capital	*Human capital*	*Reproducible capital*	*Oil net capital gains*	*Carbon damages*	*TOTAL*
United States						
1995 capital stock	5,694.73	60,086.93	13,430.66			**79,212.320**
2000 capital stock	5,702.41	64,802.68	15,923.83			**84,889.968**
Change 1995–2000	7.68	4,715.75	2,493.17	−1,367.38	−171.572	**5,677.648**
Percentage change	0.13%	7.85%	18.56%			**7.17%**
Growth rate	0.03%	1.52%	3.46%			**1.39%**
China						
1995 capital stock	3,854.52	8,492.93	3,706.23			**16,053.680**
2000 capital stock	3,847.62	9,394.69	6,471.69			**19,398.916**
Change 1995–2000	−6.90	901.76	2,765.46	−305.80	−9.284	**3,345.236**
Percentage change	−0.18%	10.62%	74.62%			**20.84%**
Growth rate	−0.04%	2.04%	11.79%			**3.86%**
Brazil						
1995 capital stock	2,688.40	7,157.81	1,728.80			**11,575.010**
2000 capital stock	2,619.42	8,248.34	1,756.91			**12,463.094**
Change 1995–2000	−68.98	1,090.53	28.11	−119.05	−42.526	**888.084**
Percentage change	−2.57%	15.24%	1.63%			**7.67%**
Growth rate	−0.52%	2.88%	0.32%			**1.49%**

Environment and Development Economi

Arrow et al. (2012), Sustainability and the Measurement of Wealth

Comprehensive Wealth and Sustainability

Table 2. *Continued*

	Natural capital	*Human capital*	*Reproducible capital*	*Oil net capital gains*	*Carbon damages*	***TOTAL***
India						
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%**
Venezuela						
1995 capital stock	3,704.417	526.61	201.21			**4,432.237**
2000 capital stock	3,591.29	587.62	204.71			**4,383.615**
Change 1995–2000	−113.131	61.01	3.51	322.04	−11.552	**261.866**
Percentage change	−3.05%	11.59%	1.74%			**5.91%**
Growth rate	−0.62%	2.22%	0.35%			**1.15%**

Arrow et al. (2012), Sustainability and the Measurement of Wealth

Comprehensive Wealth and Sustainability

Table 3. *Growth rates (%) 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
United States	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

Note: The TFP growth rate reported in column (4) is obtained from Klenow and Rodriquez-Clare (2005).

Arrow et al. (2012), Sustainability and the Measurement of Wealth

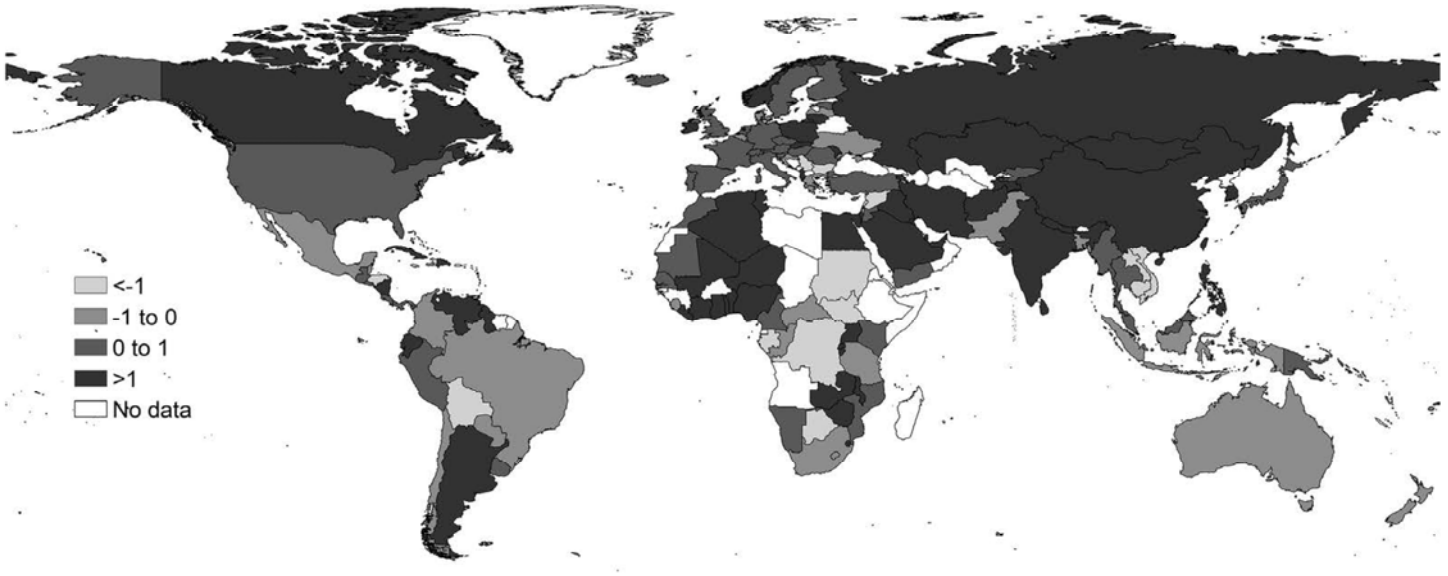
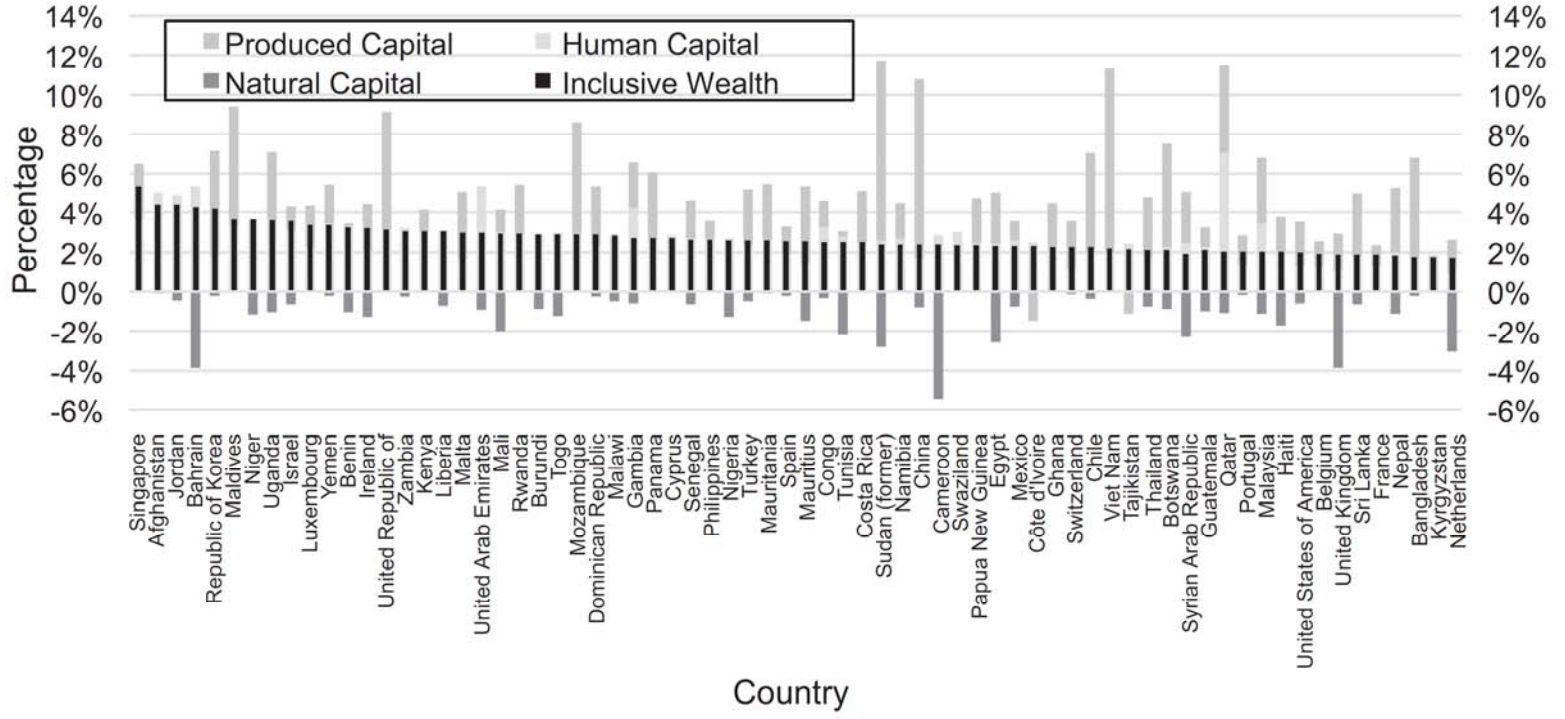


Figure 1.4b Growth in Inclusive Wealth Index per capita (adjusted)

Figure 1.4 Annual average growth rate in IWI and IWI per capita after adjustments for 140 countries assessed in the IWR 2017 during the period of 1990 and 2014

Inclusive Wealth Report (2018), *United Nations Environment Program*



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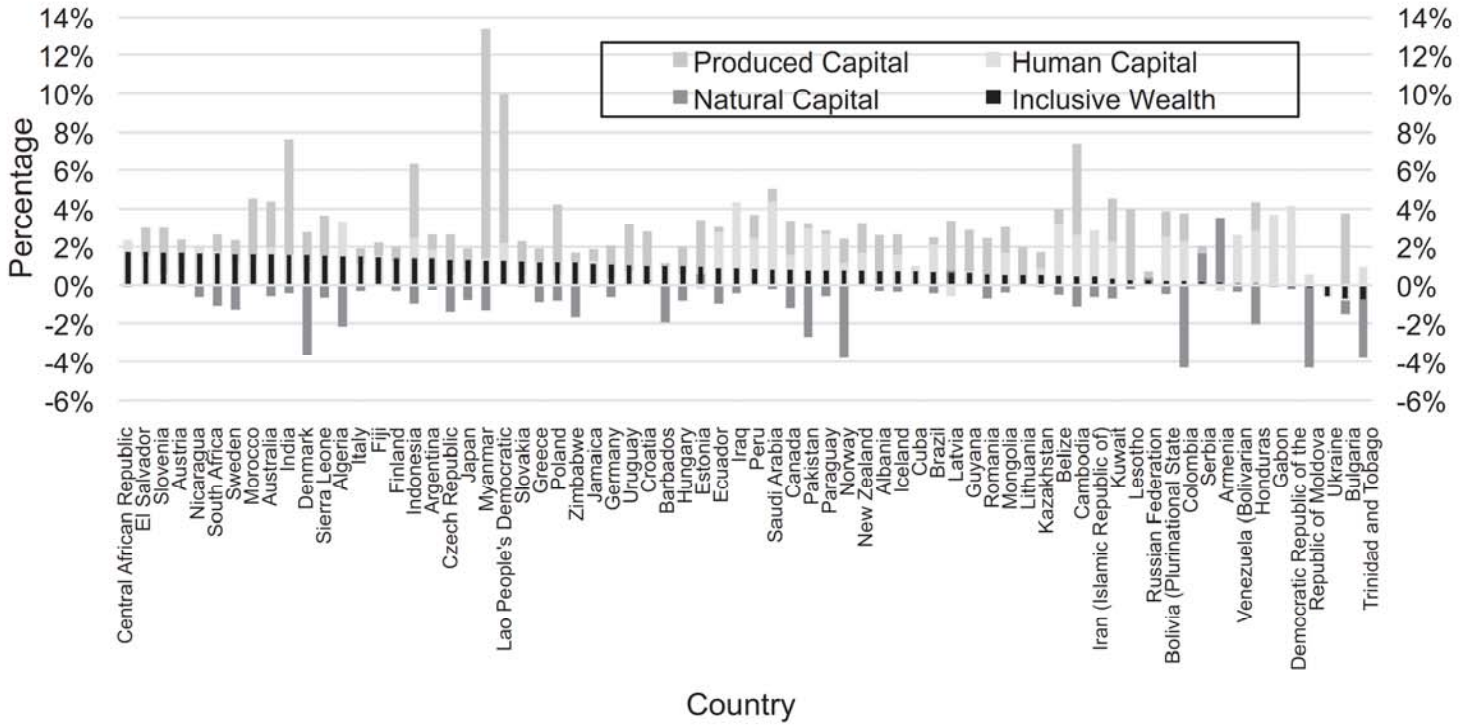

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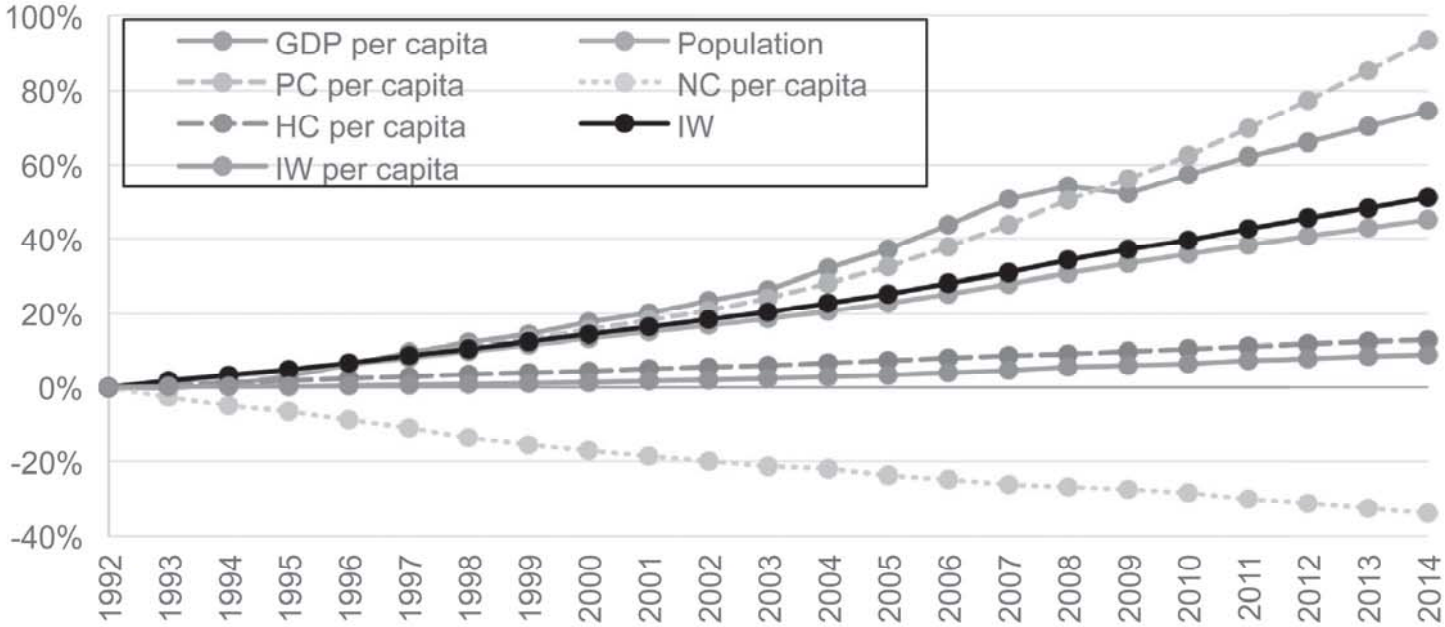


Figure 1.7 Changes in worldwide inclusive wealth per capita and other indicators for 1992–2014

Inclusive Wealth Report (2018), *United Nations Environment Program*

Challenges

- measuring stocks consistently across economies
- inclusion of health and value of life in human capital
- appropriate measuring of shadow prices

"The paucity of estimates of the value of natural capital that are grounded in economic capital theory suggests that in practice the treatment of nature as capital remains largely metaphorical."

Fenichel and Abbott, JAERE (2014)

Promising Directions

Fenichel and Abbott, JAERE (2014)

$$u(c, S) \qquad \dot{S} = r(S) - c(S)$$

$r(S)$: ecological growth function

$c(S)$: anthropogenic impact function

$$\dot{q} = \delta q - u_S(c, S) - q\left[r_S(S) - c_S(S)\right] \quad \rightarrow \quad q = \frac{u_S(c, S) + \dot{q}}{\delta - \left[r_S(S) - c_S(S)\right]}$$

Promising Directions

Fenichel and Abbott, JAERE (2014)

$$q = \frac{u_S(c, S) + \dot{q}}{\delta - [r_S(S) - c_S(S)]}$$

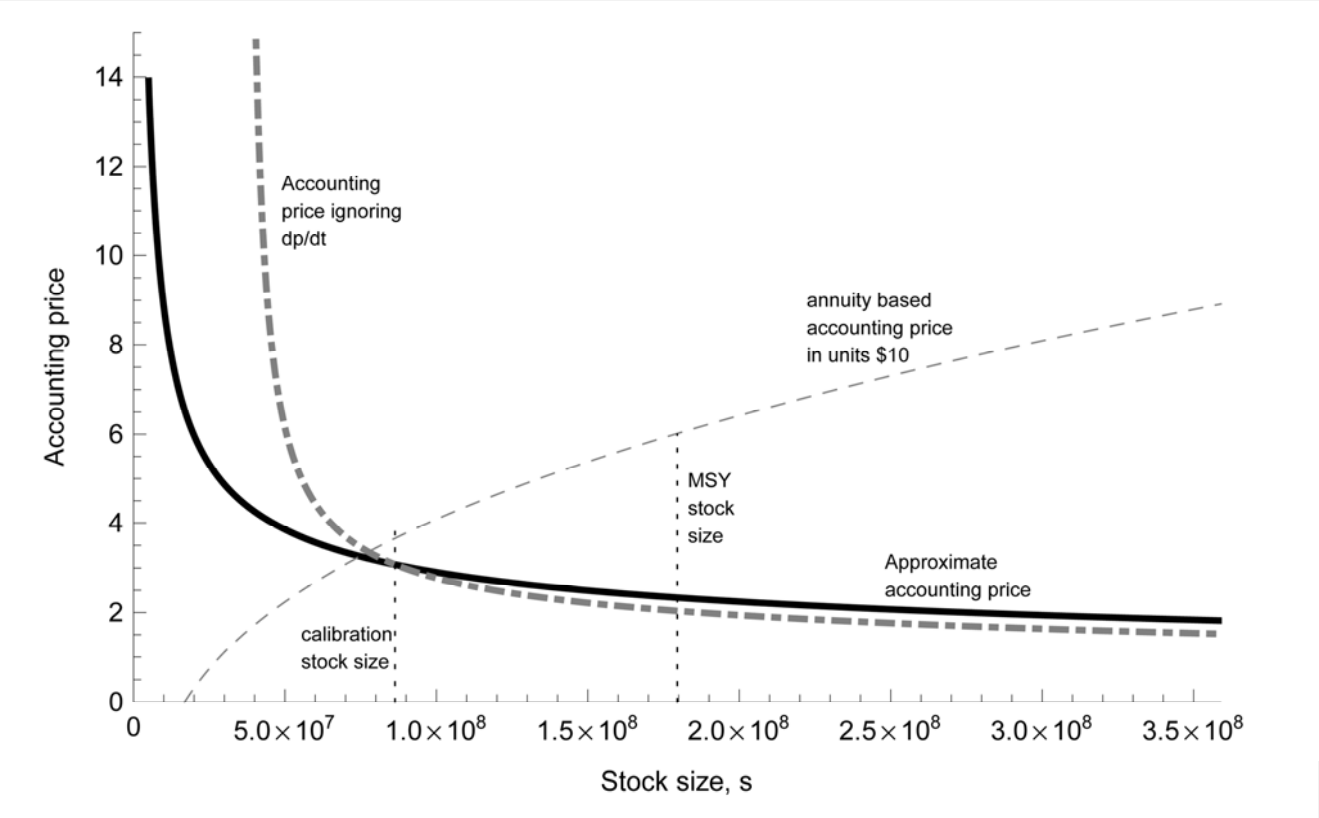
$u_S(c, S)$: static effect on economic surplus measures of changes in the stock of natural capital

$r_S(S)$: ecological studies on marginal productivity of natural capital in the absence of human intervention

$c_S(S)$: interdisciplinary studies on anthropogenic impact on stock of natural capital

$\dot{q}$: Fenichel and Abbott use **polynomial function approximation method**

Promising Directions



Accounting Prices of The Gulf of Mexico Reef Fish, Fenichel and Abbott (2014)

Summing Up

- Comprehensive Wealth accounting promising development that will bring hard figures into the sustainability debate

- Interdisciplinary approach absolutely necessary

- "Growth", "Asset Pricing" and "Optimal Portfolio Allocation" aspects of the challenge places the research question squarely within Macroeconomics