Industrial Ecology, Resource Decoupling, and the “Master Equation”

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Global Zinc Use, 1700-2000

Year

Usage (Tg/year)
Histories of Australian Ore Grades, 1845-2007
Is this a recipe for trouble?
Defining Decoupling

- **Relative decoupling**
- **Absolute decoupling**

- Economic activity (GDP)
- Resource use

TIME

Resource use
Japanese Resource Decoupling

![Graph showing the trend of Japanese Resource Decoupling 1981 to 2002 with the y-axis labeled 'thousand yen/metric ton' and the x-axis labeled from 1981 to 2002.]
The “Master Equation”

Overall Environmental/Sustainability Impact =

\[
\text{Pop.} \times \frac{\text{GDP}}{\text{person}} \times \frac{\text{resource use}}{\text{GDP}} \times \frac{\text{envt./sust. impact}}{\text{unit of resource use}}
\]
Projected World Population to 2150

Three scenarios

High Fertility: 2.6 Children per Woman
Medium Fertility: 2.1 Children per Woman
Low Fertility: 1.6 Children per Woman

GDP per capita: World, Middle East & Syria

IF database, base model projections

- World GDP per capita
- Middle East GDP per capita
- Syria GDP per capita

Year | World GDP per capita | Middle East GDP per capita | Syria GDP per capita
--- | --------------------- | ---------------------------- | ---------------------
2000 | 5.183                | 5.126                       | 3.231                
2020 | 7.859                | 8.782                       | 4.230                
2030 | 10.283               | 11.730                      | 5.087                
2040 | 13.491               | 14.834                      | 6.064                
2050 | 17.323               | 19.959                      | 8.507                
2060 | 21.745               | 26.315                      | 11.560               
2070 | 27.404               | 35.414                      | 15.354               
2080 | 34.939               | 46.628                      | 21.622               
2090 | 44.592               | 60.789                      | 29.232               
2100 | 56.588               | 79.116                      | 42.580               

Source: www.faculty.fairfield.edu/.../Oct16/Part4.html
Copper Stock per capita

New Haven: 137 kg Cu
Beijing: 35 kg Cu
Copper Stock and Copper Need

New Haven: 137 kg Cu

Beijing: 137 kg Cu

1.3 Pg Cu

Global need in 2040
Limits to Materials: Copper Stock and Copper Supply

New Haven: 137 kg Cu

Beijing: 137 kg Cu

Global need in 2040: 1.3 Pg Cu

Global resource: 1.6 Pg Cu
Ad in Newsweek
August 20, 2001

THERE ARE NO TVs TOO BIG. ONLY ROOMS TOO SMALL.
A Typical Water Treatment System
Copper Use as a Function of Wealth

[Graph showing the relationship between GDP per capita, PPP (current international $), and copper per capita entering use (kg/yr) for various countries such as South Korea, Malaysia, USA, Japan, Germany, Kazakhstan, and others.]
The Master Equation

Overall Environmental Impact =

\[
\text{Population} \times \frac{\text{GDP}}{\text{person}} \times \frac{\text{resource use}}{\text{GDP}} \times \frac{\text{environmental impact}}{\text{unit of resource use}}
\]

\[
\frac{2050}{2010} \quad 1.5 \quad 3 \quad 2 \quad ??
\]
Environmental Improvement in The Netherlands

- GDP
- CO₂ emissions
- Waste generation

1980 2010
Embedded Energy for Different Industrial Materials

Highland Valley Canada Copper Mine Empoundment

Source: swittersb.wordpress.com/2008/08/
Implications for Policy of Resource Supply and Use

• Virgin resources are being used at increasing rates
• We demand resources without a good idea of the ultimate quantities available for extraction
• The master equation demonstrates that absolute decoupling will be a product of addressing the technical and societal relationships that link personal wealth, development, and consumption
• New recycling technology and design for recycling will help, but major cultural changes to “dematerialize” wants and needs are probably the most effective way to insure long term sustainability
The Challenge of Decoupling Needs and Wants from Their Realization