A comprehensive approach to model abiotic resource provision capability in the context of sustainable development

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AGENDA

- INTRODUCTION
- FRAMEWORK AND METHODOLOGY
- RESULTS
- CONCLUSIONS AND OUTLOOK
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What needs to be secured?

- Functionality of materials → availability at a certain point in time (now or in the future)
  - need to sustain availability for future generations
  - need to sustain access to resources for current generations
- Resource provision capability rather than availability in nature → all dimensions need to be considered

→ From a one-dimensional approach to a multi-dimensional approach
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Framework: Forms of scarcity

Demand of material in limited supply

Scarcity

Long-term concerns

Physical scarcity (caused by depletion)

Short-term concerns

Effective scarcity (caused by constraints in the supply chain)
**Physical and effective scarcity I**

<table>
<thead>
<tr>
<th>Physical scarcity</th>
<th>Effective scarcity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Problem: Depletion</td>
<td>Problem: Supply risk</td>
</tr>
<tr>
<td>Focus: Future generations</td>
<td>Focus: Current generations</td>
</tr>
<tr>
<td><strong>Consequence of</strong> resource use today</td>
<td><strong>Effect on</strong> resource availability today</td>
</tr>
<tr>
<td>Scope: resource stock</td>
<td>Scope: resource flows</td>
</tr>
</tbody>
</table>
Physical and effective scarcity II

- Depletion: consequences of resource use today
- Supply risks: effects of constraints in the supply chain on resource supply
Framework: Dimensions of scarcity

Physical scarcity
- Physical constraints

Effective scarcity
- Economic (market) constraints

Effective scarcity
- Environmental constraints

Effective scarcity
- Social constraints

Resource provision capability

Human welfare

Direct constraint

Indirect constraint
Comprehensive analysis: methodological approach

- Physical AND effective scarcity need to be considered from a sustainability perspective

Objective  ➔  Forms of scarcity  ➔  Dimensions  ➔  Measurement

Physical scarcity (depletion potential)
- Assessment of resource depletion
  - Decreasing stocks  ➔  Future material security

Effective scarcity (supply risk)
- Economic supply risks
  - Criteria
- Environmental supply risks
  - Criteria
- Social supply risks
  - Criteria

Current material security
The assessment of resource depletion

- **Physical scarcity** of resources
  - decrease of resource stocks
  - considerations of depletion important for future material availability

- **Abiotic depletion potential** (ADP) - model is a good basis
  - but consideration of functional value rather than environmental availability
  - inclusion of all available stocks, including anthropogenic stocks
The assessment of supply risks

- **Supply risk** is a relative rather than absolute concept
  - determination from when certain situation becomes risk
  - inclusion of risk threshold

\[ I_{i,j} = \left( \frac{\text{actual value}_{i,j}}{\text{threshold}_{i,j}} \right)^2 \]

\( I = \text{impact factor} \)
\( i = \text{resource} \)
\( j = \text{constraint} \)

(Source: Müller-Wenk 1978; Frischknecht et al 2009)

- **Distance-to-target method**
  - application to the assessment of supply risk
  - exceedance of thresholds denotes risk to resource supply
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The economic resource scarcity potential (ESP) I

- Evaluation on a product level
  - identify hotspots
  - avoid risks, e.g. consideration of economic constraints in the design-phase
- Link to existing LCI data

**Economic supply risks**
- Market induced constraints due to geopolitical, political, technical and regulatory circumstances
- Direct effects on resource supply
  - Disruptions in the supply chain

**Economic criteria**
- Availability of reserves
- Concentration of production
- Concentration of reserves
- Company concentration
- Companion metals
- Use of recycled material
- Socio-economic stability
- Governance stability
- Demand growth
- Trade barriers
The economic resource scarcity potential (ESP) II

Application of the distance-to-target method to the different dimensions of supply risk

$$I_{ESP,i,j} = \text{Max}\left\{ \left( \frac{\text{indicator value}_{i,j}}{\text{threshold}_{i,j}} \right)^2 ; 1 \right\}$$

$I = \text{impact factor}$; $i = \text{material}$; $j = \text{impact category}$

EXAMPLE:

Country concentration for material i

$$\text{Indicator} = \text{Herfindahl index (HHI)}$$

Country concentration$_i = \text{Max}\left\{ \left( \frac{\text{HHI}_i}{0.15} \right)^2 ; 1 \right\}$

Economic resource scarcity potential (ESP)

$$ESP_i = \prod_j \left( I_{ESP,i,j} \right)$$
Testing the developed approach

<table>
<thead>
<tr>
<th>Resource</th>
<th>Mercedes S400 Hybrid (kg)</th>
<th>Mercedes S350 (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steel</td>
<td>1035</td>
<td>1006</td>
</tr>
<tr>
<td>Aluminum</td>
<td>282</td>
<td>260</td>
</tr>
<tr>
<td>Copper</td>
<td>34,4</td>
<td>24,2</td>
</tr>
<tr>
<td>Nickel</td>
<td>0,95</td>
<td>0</td>
</tr>
<tr>
<td>Cobalt</td>
<td>0,17</td>
<td>0</td>
</tr>
<tr>
<td>Lithium</td>
<td>0,13</td>
<td>0</td>
</tr>
<tr>
<td>Rare earths</td>
<td>0,221</td>
<td>0</td>
</tr>
</tbody>
</table>

(Source: Daimler 2011; Schneider et al. 2011)

ADP model – current practice

ESP model – assessing supply risks

Hybrid car

Conventional car
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Conclusions

- Comprehensive assessment of resource provision capability → complement and enhance current practice
- Inclusion of all relevant dimensions of resource provision capability
  - identify hotspots
  - avoid supply risks and negative impacts

→ New model considers potential physical, economic, environmental, and social scarcity

 Improved assessment of resource availability towards life cycle sustainability assessment
Resource efficiency assessment

- Resource efficiency is defined as

  \[ RE = \frac{\text{added value}}{\text{resource input}} \]
  
  - On EU level:
    \[ RE = \frac{GDP}{DMC} \]
  
  - On product level: mass based indicators, e.g. MIPS
ESSENZ-Method

\[
\text{RE} = \frac{\text{performance of product system}}{\text{Physical availability + socio-economic availability + environmental impacts + societal aspects}}
\]

- Abiotic resource depletion (ADP+AADP)
- Concentration of reserves
- Companion metal
- Feasibility of exploration projects
- Price fluctuation
- Mining capacity
- Trade barriers
- Concentration of production
- Political stability
- Primary material use
- Company concentration
- Demand growth
- Climate change
- Eutrophication
- Acidification
- Ozone layer depletion
- Smog
- Non compliance with social standards
- Non compliance with environmental standards

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Thank you very much!