Economic Conditions for Recycling of Waste

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1. Economy: Benefit or Harm

   It’s the economy, stupid!

   vs.

   It is stupid not to analyze economic consequences and knock-on effects without considering them when making decisions (e.g. actions, strategies or legislation).

   → Otherwise: Misallocation, dissatisfaction, disappointment
2. Thesis pertaining to Recycling

- Recycling is the talk of the town– worldwide

- Recycling is assessed as a miracle weapon allowing
  - Circular economy–model
  - Cradle to cradle (C2C)-principle
to be applied.

- Applications of Recycling
  - Re-use (Wiederverwendung) without chemical reaction
  - Re-processing (Wiederverwertung) with chemical reaction

→ Re-integration of waste, past-consumer-products, demolished buildings and infrastructure, capital goods into the business cycle again!
2. Thesis to the Recycling

- Inputs for manufacturing process
- Secondary raw materials
- Process of transformation/modification
- Waste/residues
- Formation of waste/residues
- Requirements of the process input
- Characteristics of waste/residues
- Discrepancies between waste/residues and process input

Discrepancies:
- Kind of materials
- Qualities
- Availability concerning volume, location, time
- Price differences between primary- and secondary-raw materials
- Attitudes of the consumers

Strategy: Change the requirements of inputs
- Modifications of the residues of production processes and post consumer products
- Strategy: Change the technical characteristics of waste/residues

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Recycling is only a means to an end.

Thus: Recycling is an instrument, but not an objective.

Consequently, maximization of recycling activities
- makes no sense (respectively)
- can be counterproductive

Consider a UNEP-report from 2013:

Cradle to cradle (C2C)-concepts are useful psychological tools for drawing people's attention to recycling, but should not to be used as a basis for policies.

3. Recycling is not an Objective but an Instrument

Recycling is an option in terms of

- Measures for waste disposal (municipal waste, end-of-life-products, demolition waste)
- Procedures for linked productions

i.e.: Description of linked productions:

- Desired outputs = products
- Undesired outputs = conducts:
  - co-product (positive market value)
  - by-product (negative market value)
  - waste (disposal fee)
Recycling of Waste

Input conducts (after process step 1)

- Direct marketing without additional conditioning process
  - Market profit
  - Additional payment
    - Co-product (a)
    - By-product (b)
  - Market profit > manufacturing costs for process step 2
    - Co-product (c)
    - Co-product (d)

- Direct marketing after conditioning process
  - Process step 2
    - Market profit
    - Manufacturing costs for process step 2 plus additional payment
      - By-product (e)

- Disposal by waste disposal system
  - Additional payment
  - Waste (f)

Manufacturing costs for process step 2 plus additional payment

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→ (a) competing against (c)
→ (b) competing against (d) and (e)
→ (a), …., (e) competing against (f)

**Note:** In addition to the direct cost of the process step 2
(~ processing and marketing), additional investment costs may still occur:

- development costs of the processing method
- transaction costs (i.e. in particular market development costs, negotiation costs, securing permanent purchase,...)
4. Benefits and Limits to Recycling – selected Aspects

- Intergenerational justice (availability of resources & environmental quality for future generations)
- Emissions reduction & climate protection
- Recycling as „backstop-technology“ in view of actual scarcity of resources and unavailability of substitutes.
- Security of supply in connection with geopolitical risks. (e.g. quasi-monopoly of China in rare earth metals ⇒ market share > 90%)
4. Benefits and limits of recycling – selected Aspects

- Fluctuation in the degree of purity reduce the value and usability of recyclate.
  - In extreme (but not uncommon) cases (e.g. contamination with hazardous substances) the recyclate becomes hazardous waste
  - The higher the actual recycling rate the higher the degree of contamination with foreign matter.

- Specific problems with plastics (composites / fiber laminates):
  
- Miniaturization: Very little recyclable fractions (e.g. in mobile devices)
  - Extraction of resources is complex and expensive.
5. Empirical Findings regarding Recycling

Where do the EU countries stand?

- "Ternary diagram"

- EU average
  - appr. 35 % landfill
  - appr. 25 % incineration
  - appr. 40 % recycling

- Each country has its own positioning

Source: Pomberger, R., Montanuniversität Leoben

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5. Empirical Findings regarding Recycling

Countries with recycling and incineration of municipal waste to a great extent

Countries with landfill of municipal waste to a great extent

"Transitions countries"

Source: Pomberger, R., Montanuniversität Leoben

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Does the price level of waste disposal services stimulate recycling activities?
(Company survey in Germany and Japan; Baum/Sakai/Ueta)

Relative waste disposal costs to the relative recycling investment (own research)

Main result: The higher the relative price/fee for waste disposal services; the higher the relative recycling activities

→ The price mechanism does really work in the field of waste management indeed!

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6. An Economic Model fixing an appropriate Recycling Quota

Transformation:
From a **linear** to a **circular** thinking
From a **static** to a **dynamic** thinking
→ New potentials, targets and actions!

Essential empirical knowledge:
Secondary raw material is basically not suitable for re-utilization in the original field of application!
(e.g.: Secondary raw materials based on food packagings can't be re-used as food packaging, (forbidden due to hygienic and microbiological issues))

→ Re-utilizations require a mix of primary and secondary raw materials!
→ Re-utilizations require a special investment to create new markets (new applications, new customers)!
6. An Economic Model fixing an appropriate Recycling Quota

- \( U = (\text{ecological} \text{ utility}) \)
- \( R = (\text{product} \text{-} \text{revenue}) \)
- \( C = \text{cost} \)

- \( U^{\text{max}} = \text{ecological maximum} \)
- \( R^{\text{max}} = \text{revenue maximum} \)
- \( R = C = \text{cost-covering budget maximum} / \text{sales (recyclate revenues)} \)
Marginal Analysis to identify optimal Recycling Quota

- $U' = \text{(ecological) marginal utility}$
- $C' = \text{marginal cost}$
- $R' = \text{marginal revenue (recyclate)}$

- $R' = C'$ (business) profit maximum (product revenues = recyclates)
- $R = C = \text{cost-covering budget maximum / sales (recyclate revenues)}$
- $U' = C' = \text{overall (economic and social) optimum}$
- $\Delta^+ \text{ to be closed by regulatory measures (taxes, binding recycling rates etc)} / \Delta^- \text{ also to be closed}$

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The Dynamics of Recycling – Learning Process

(ecological) utility: $U$

cost: $C$

(recyclate-)revenue: $R$

$U_1$ $\leftrightarrow$ $U_2$ = emissions reduction in the scope of collecting & recycling (e.g. renewable energy)

$C_1$ $\leftrightarrow$ $C_2$ = cost reduction due to process innovation and competition

$R_1$ $\leftrightarrow$ $R_2$ = innovation (higher quality of recyclates) & development and exploitation of new markets
7. Conclusion (1)

- Generally, there isn't any business model of recycling created only by the forces of a free market. Regulatory instruments (as directives, fees, obligatory recycling rates, …) are necessary.

- But: The price mechanism can help to promote the circular economy based essentially on secondary raw material.

- Recycling is an option and not an objective. After a certain number of loops the generated secondary raw material has been generally enriched with a higher degree of contamination and the quality has deteriorated essentially (Exception: metals). That means: Waste disposal is an inevitable part of a recycling economy.
7. Conclusion (2)

- Maximization of the recycling quota isn’t a reasonable target, but optimization is the proper way!

- Carbon based primary resources (as coal, gas, oil, …) aren’t really scarce for the next several hundred years. But the climate change due to greenhouse gas is the challenge.

- Sustainability of recycling requires competitiveness and substitution of primary resources. This process can be encouraged by subsidies and innovative circumstances.