

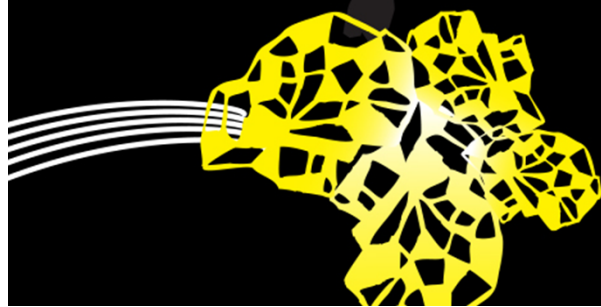
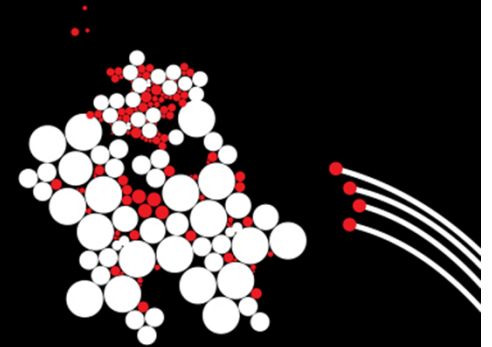
UNIVERSITY OF TWENTE.

NEW PERFORMANCE INDICATORS FOR INDUSTRIAL SYMBIOSIS: AN ECOSYSTEM APPROACH

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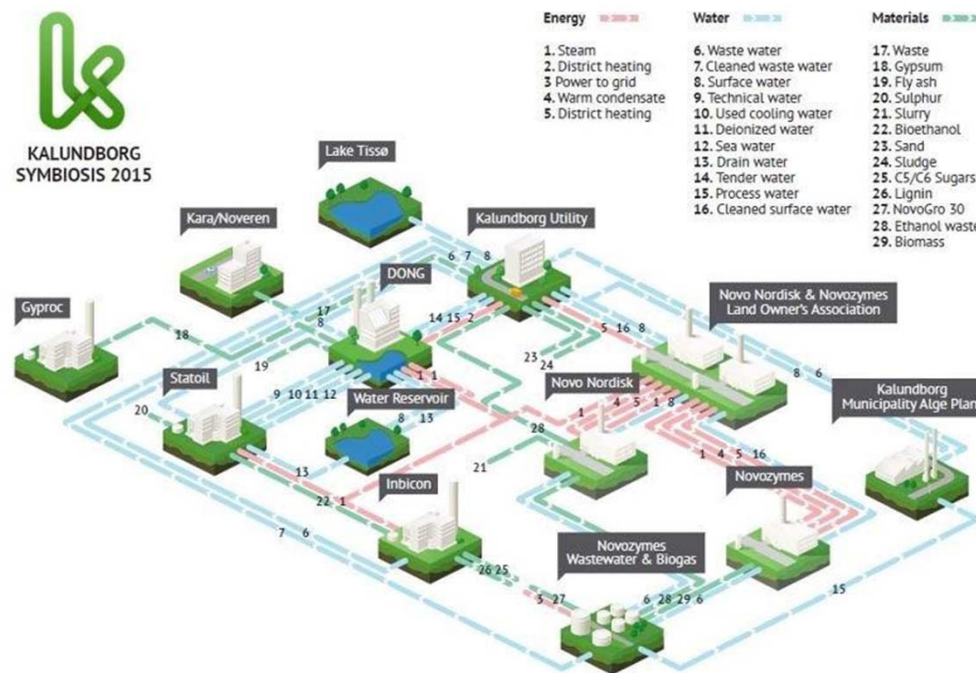
AGENDA

- Introduction
- Aim of the study
- Methods
- Performance indicators of functions
- Performance indicators of firms
- Case example
- Conclusions



STARTING WITH... A QUESTION

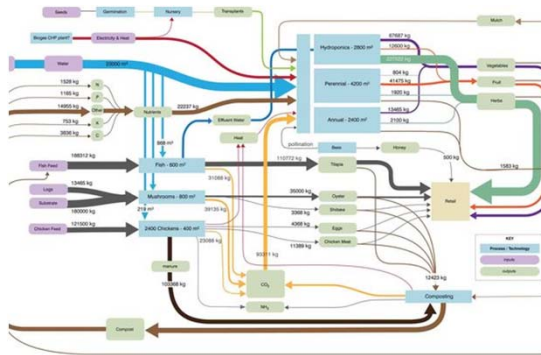
WHEN INDUSTRIAL SYMBIOSIS NETWORKS ARE WORKING OPTIMALLY?



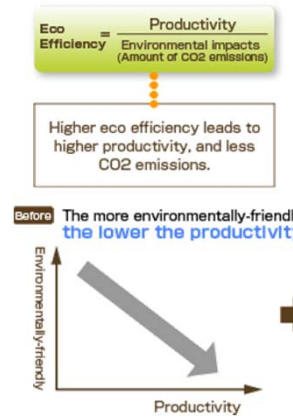


INDUSTRIAL SYMBIOSIS INDICATORS

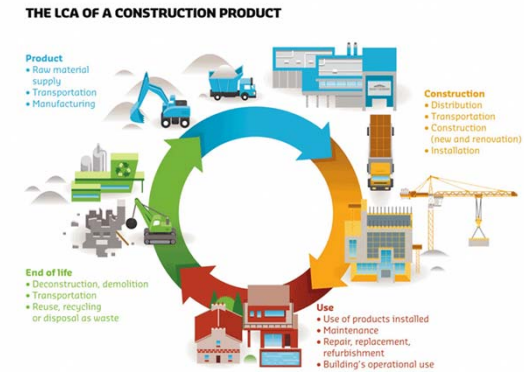
EVIDENCE FROM THE LITERATURE



Material flow analysis



Eco-efficiency



Life-cycle assessment



AIM OF THE STUDY

- Designing indicators assessing
 - ✓ Performance of each waste exchange within Industrial Symbiosis Networks
 - ✓ The extent to which each firm contributes to these exchanges



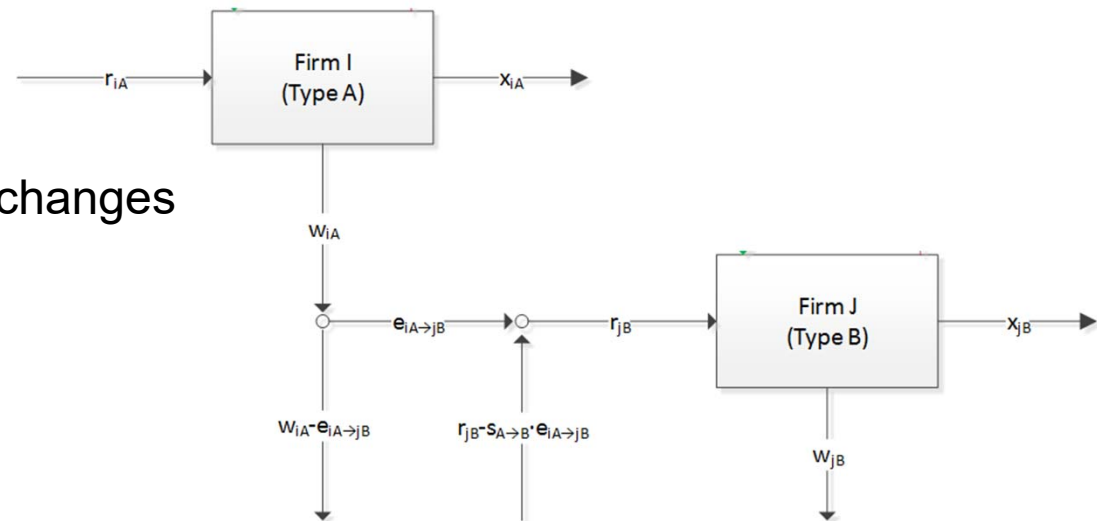
METHODS

- ISNs framed as ecosystems ([Korhonen, 2001](#))
 - ✓ Organisms = Firms
 - ✓ Functions = (1) recovering the produced wastes and (2) replacing the required inputs
 - ✓ Firms contribute to functions by producing, requiring, exchanging wastes
 - ✓ Services generated by Industrial Symbiosis Networks
 - Creating economic benefits for firms
 - Creating environmental benefits for the collectivity
- Flows among firms modeled by input-output approach ([Fraccascia et al., 2017](#))



ENTERPRISE INPUT-OUTPUT MODELING

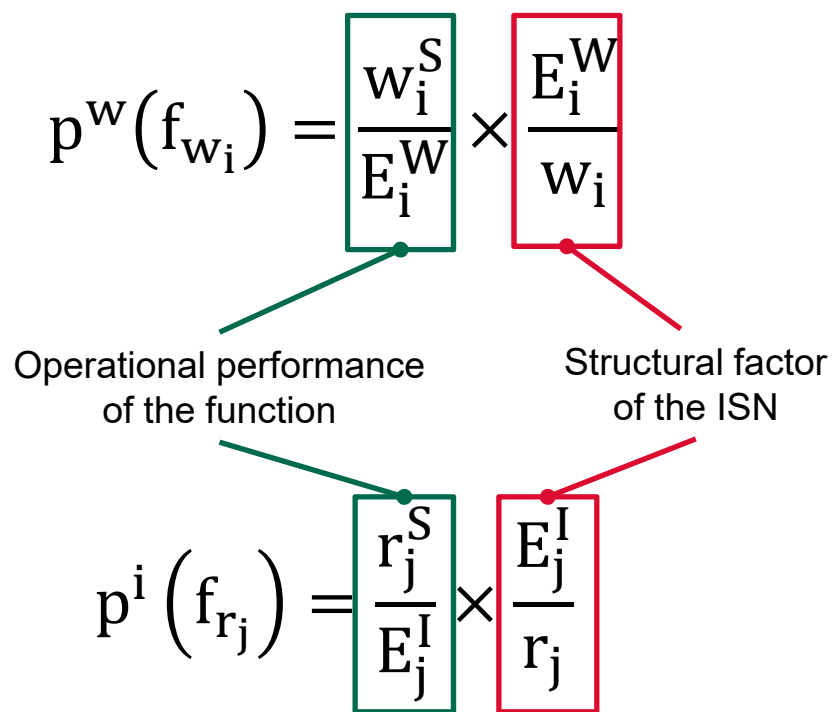
- Waste production
- Input requirement
- Feasible symbiotic exchanges





PERFORMANCE INDICATORS OF FUNCTIONS

"RECOVERING WASTE i " AND "SAVING INPUT j "



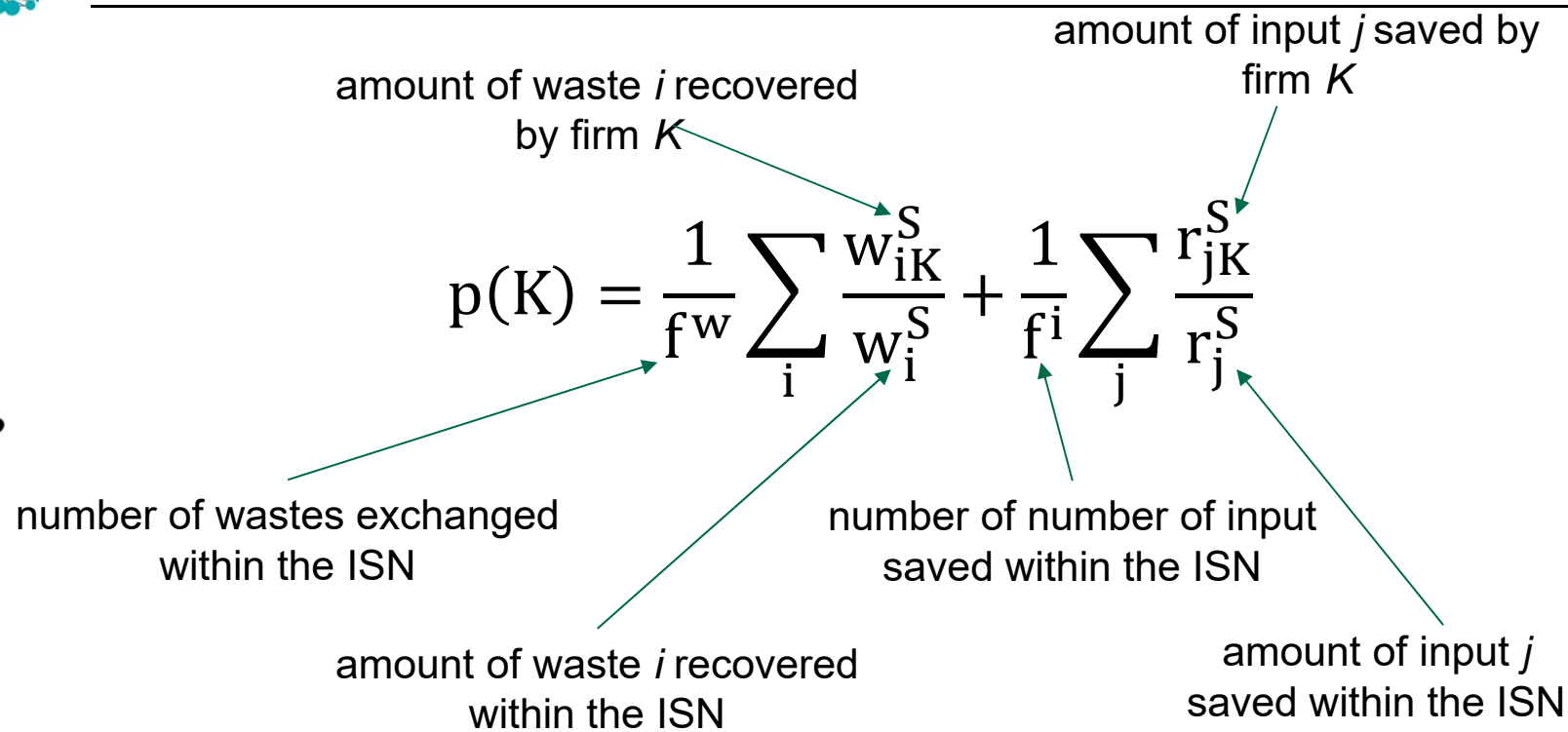
w_i^S = amount of waste i recovered
 w_i = amount of waste i produced
 E_i^W = highest amount of waste i which can be recovered

r_j^S = amount of input j saved
 r_j = amount of input j required
 E_j^I = highest amount of input j which can be saved



PERFORMANCE INDICATOR OF FIRMS

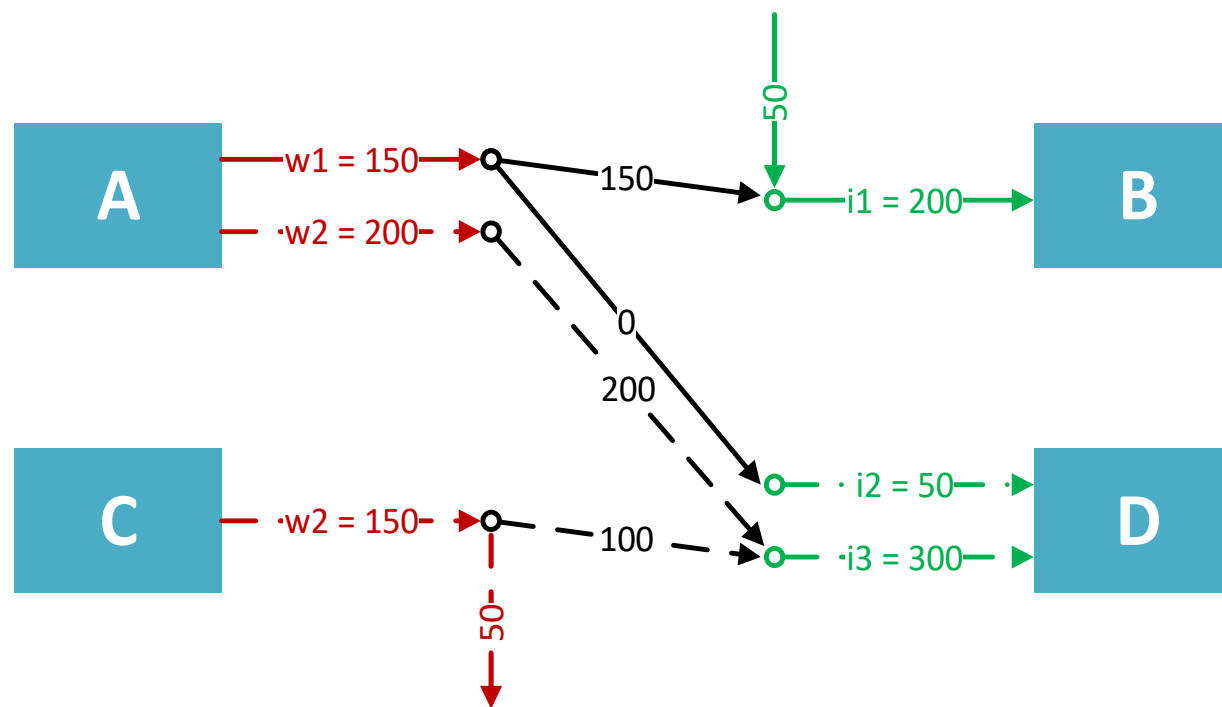
"PERFORMANCE OF FIRM K "





TESTING THE INDICATORS

A CASE EXAMPLE (1/3)

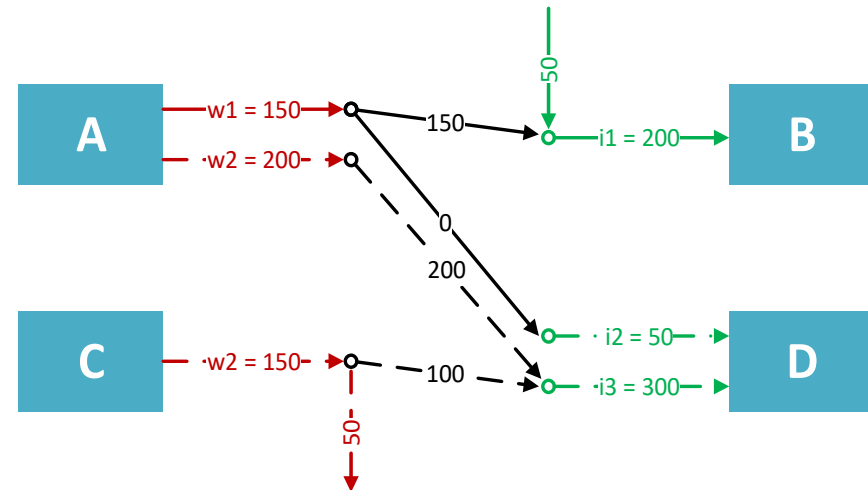




PERFORMANCE OF FUNCTIONS

A CASE EXAMPLE (2/3)

- $p^W(f_{w_1}) = \frac{150}{150} \times \frac{150}{150} = 1$
- $p^W(f_{w_2}) = \frac{300}{300} \times \frac{300}{350} = 0,8571$
- $p^i(f_{i_1}) = \frac{150}{150} \times \frac{150}{200} = 0,75$
- $p^i(f_{i_2}) = \frac{0}{50} \times \frac{50}{50} = 0$
- $p^i(f_{i_3}) = \frac{300}{300} \times \frac{300}{300} = 1$

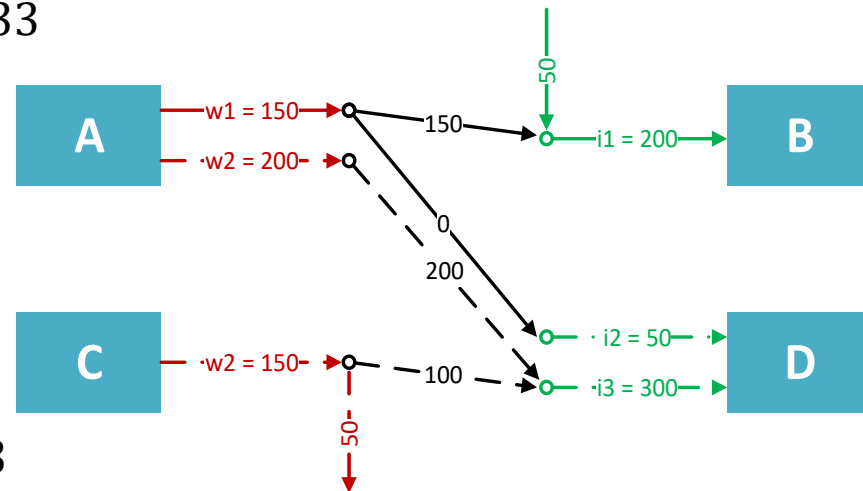




PERFORMANCE OF FIRMS

A CASE EXAMPLE (3/3)

- $p(A) = \frac{1}{2} \left[\frac{150}{150} + \frac{200}{300} \right] + 0 = 0,8333$
- $p(B) = 0 + \frac{1}{3} \left[\frac{150}{200} \right] = 0,25$
- $p(C) = \frac{1}{2} \left[\frac{100}{300} \right] + 0 = 0,1667$
- $p(D) = 0 + \frac{1}{3} \left[0 + \frac{300}{300} \right] = 0,3333$





(WHY) ARE THESE INDICATORS USEFUL?

- They highlight
 - ✓ Functions currently underdeveloped compared to their potential
 - Which?
 - Why?
 - ✓ Firms providing the strongest contribution to the symbiotic network



Thank you for your attention!

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