UNIVERSITÀ DEGLI STUDI DI BRESCIA

Network analysis as a tool for planning industrial symbiosis in the framework of regional policies: case study from Brescia

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Industrial Symbiosis at Regional Scale

Industrial symbiosis brings many benefits such as resource efficiency and reduction of emissions to a region, specially if facilitated trough regional policies rather than being preformed by individual attempts, however there are challenges in its implementation due to shortcomings in the following aspects:

- The lack of policy development
- The limitation of investments on symbiotic innovative solutions by companies
- The culture of collaboration among the industries
- The lack of operational information about the possibilities for input/output matching of resources

Industrial Symbiosis Implementation

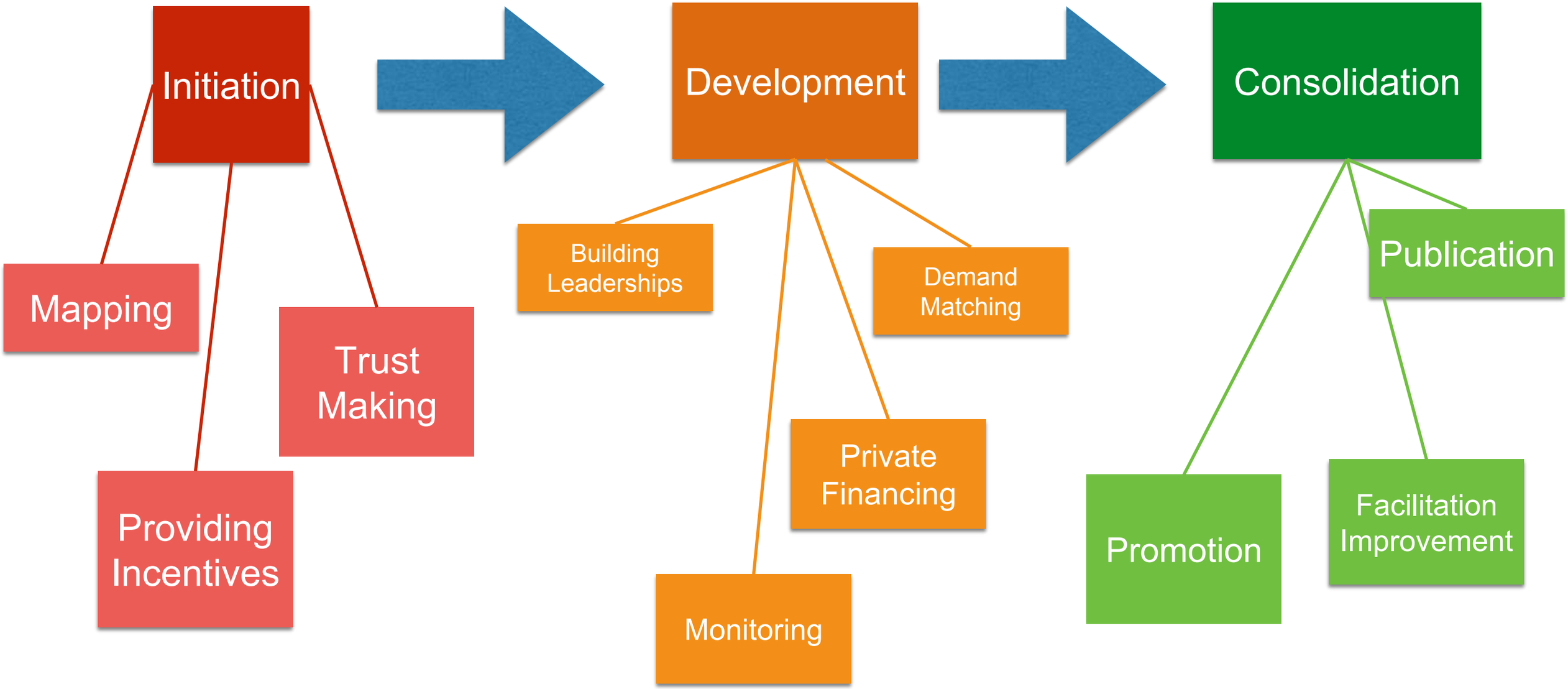
A 3-phases pattern for implementation of the regional industrial symbiosis is adopted, based on a 11-steps methodology proposed by Moodie et al. (2019) including:

TRUST – MAPPING – INCENTIVES – FINANCING – DEMAND – STRONG LEAD – MATERIAL FLOWS –BEST PRACTICES – VISION – PROMOTION – CONDITIONS

Considering the whole process in a time framework, certain activities are needed to be preformed by the facilitator (regional policy maker) in order to achieve all the steps.

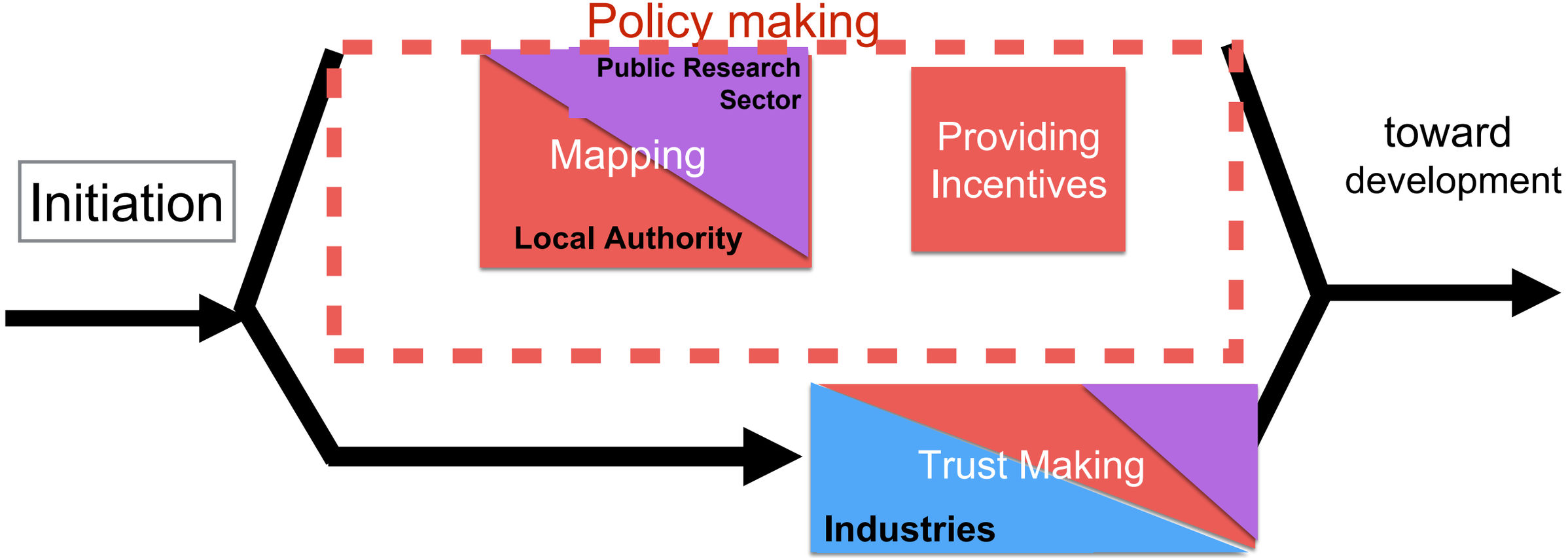
Moodie, J., Salenius, V., Leino, J. (2019). Industrial Symbiosis in the Baltic Sea Region : Current Practices and Guidelines for New Initiatives. Stockholm: Nordregio. https://doi.org/10.30689/PB2019:1.2001-3876

Regional Industrial Symbiosis Implementation



Initiation Phase: Between Planning and Facilitation

This is widely accepted that the presence of a facilitator is inevitable in forming a long-lasting symbiosis collaboration and specially if the objective is to grow the symbiotic collaborations to a regional scale.



Developing a strategy for initiating

Considering policy making as “Mapping + Incentive providing”, we may start with mapping which includes the activities in the following three groups in order to know the problem and provide the proper solutions:

- Formation of joint-meetings with the industries in different sectors to collect and share information
- Following the pervious experiences and achievements of other networking activities in the region
- Starting with a series of calculation and data processing by using indicators defined on the basis of scientific researches

Social Network Analysis (SNA) for evaluation of industrial symbiosis potentials as a part of mapping step

- SNA initiated to be used in the early 1920s.
- Focusing on relationships between different sets of social entities.
- Applied as a quantitative method for analyzing social interactions in many fields, including resource utilization, social communication, etc.
- Social network structures can be characterized by their Nodes (individuals, actors, units, or other items in a network) and Edges (interactions or relationships)
- Usually the networks are visualized by graphs.

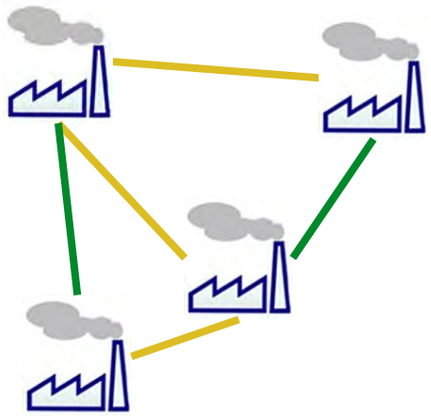
Steps in network analysis for IS initiation

- Contextual considerations
- Identifying the Network players
- Analysis and visualization of the Network
- Developing strategies

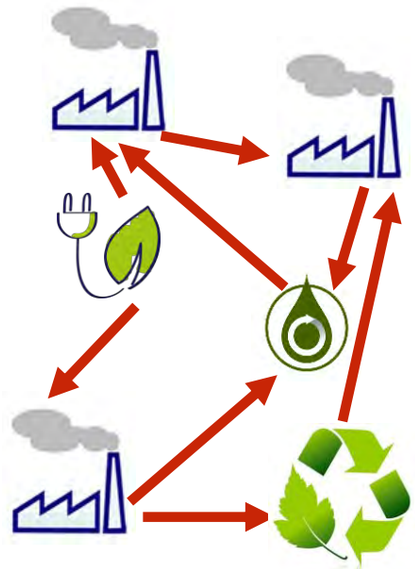
Contextual Considerations

- Working with local basic databases
- Considering geo-spatial distribution and industrial diversity
- Considering territorial plans
- Evaluating the context and selecting the focus points

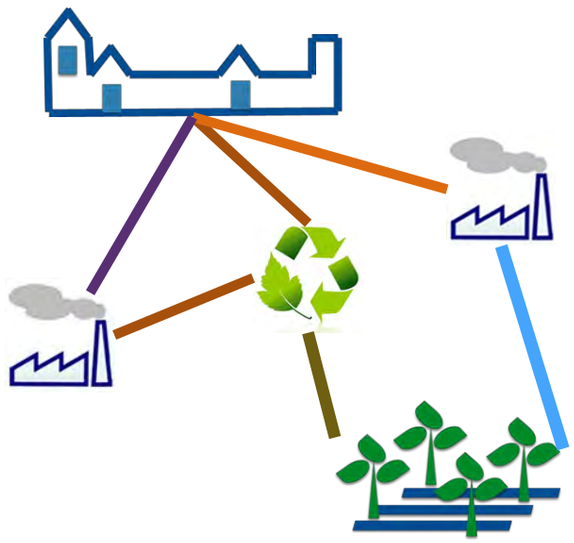
Scope of the study (identification of the IS players)



Type A: IS network limited only to manufacturers



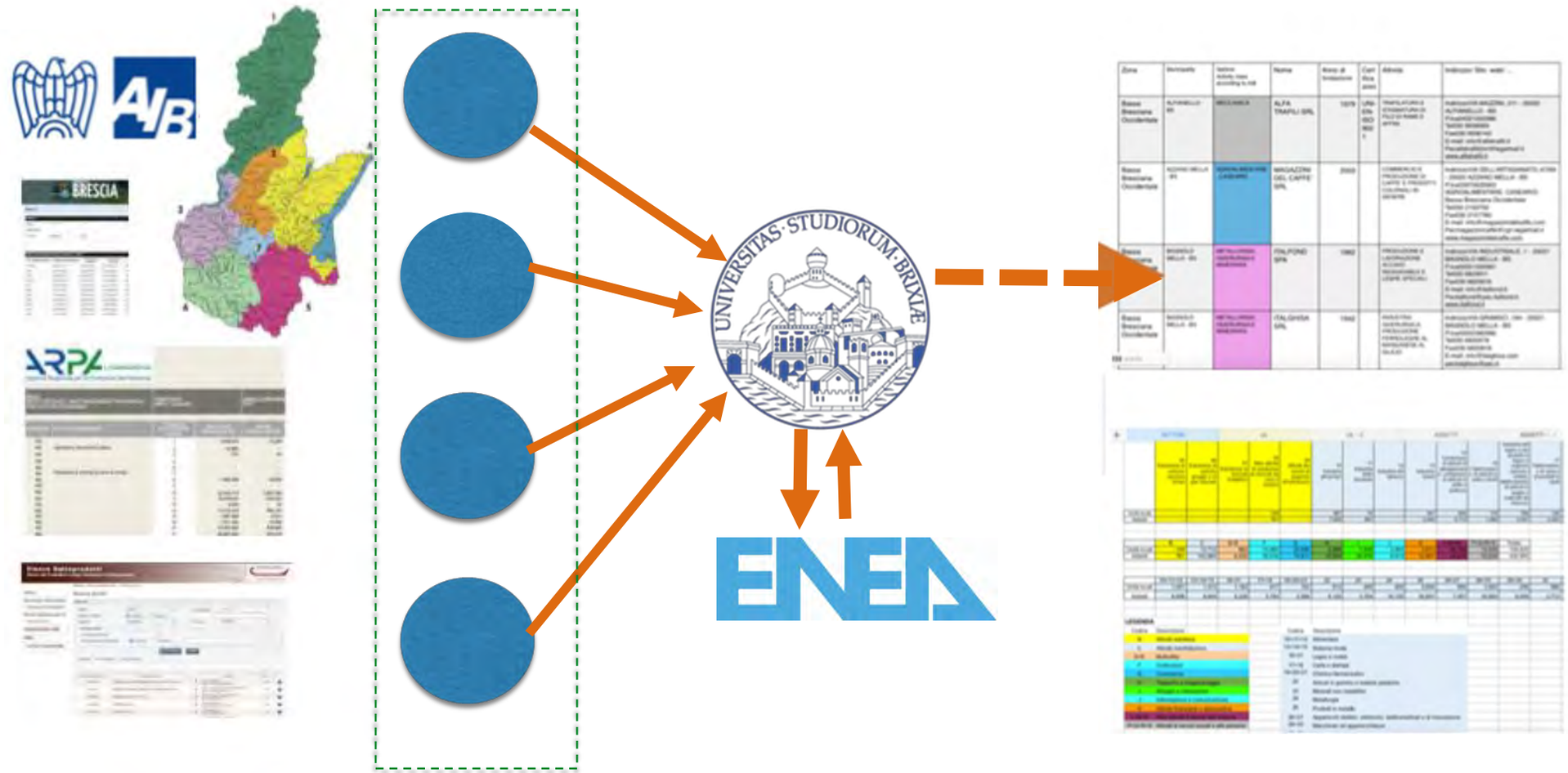
Type B: IS network including also the waste treatment companies



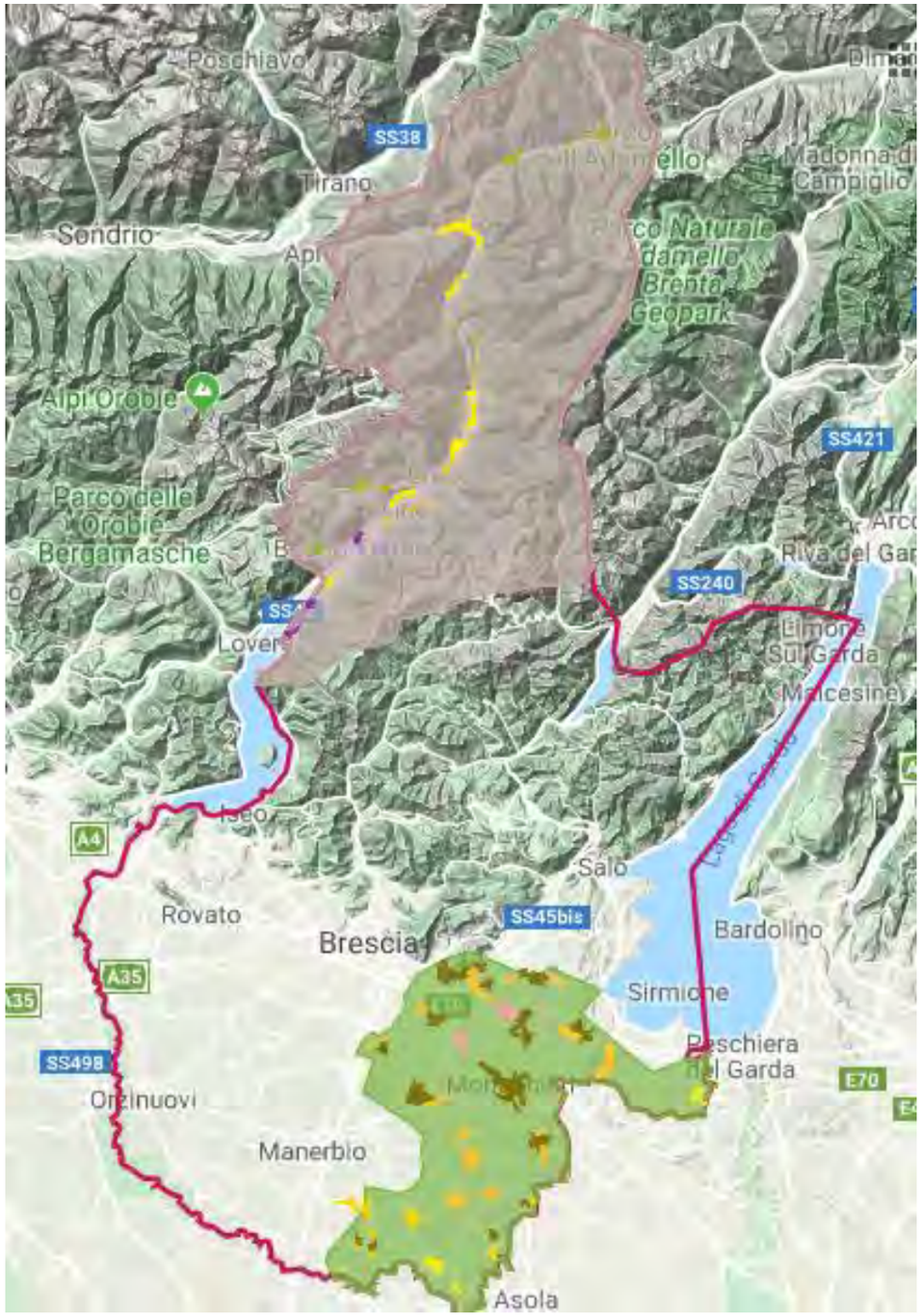
Type C: IS network including also players from municipality and agricultural sectors

For a comparison between two different types of regional industrial symbiosis, see: Baas, L. (2011). Planning and Uncovering Industrial Symbiosis: Comparing the Rotterdam and Östergötland regions Business Strategy and the Environment 20, 428–440

The Process of Data Collection



Geo-spatial distribution and industrial diversity

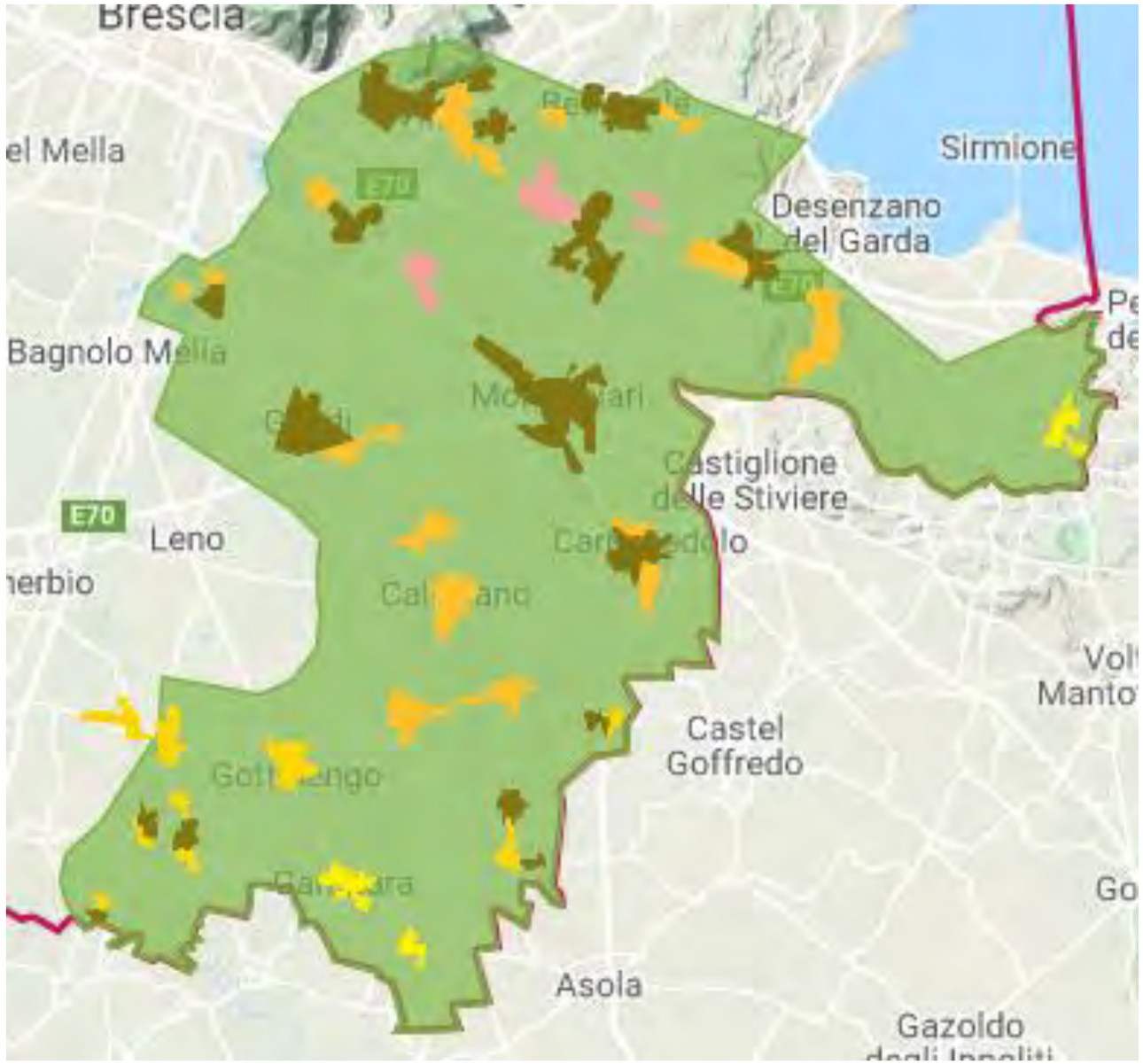


Typical distribution of industrial activities in south – eastern part of the province (Zone n. 5)

The industrial diversity

Calculating the Simpson's diversity index (D), and (1-D) Values, (Jensen 2015)

$$D = \sum_{i=1}^{sR} \left(\frac{n_i}{N} \right)^2$$



Jensen, P. D. (2016). The role of geospatial industrial diversity in the facilitation of regional industrial symbiosis Conservation and Recycling.

Resource 107, 92–103

The distance of exchanges

Review of scientific literature

- Average resource movement, 34 km, for collaborations based on IS experiences in England and Scotland (Jensen et al. 2011)

Practical case studies in Italy

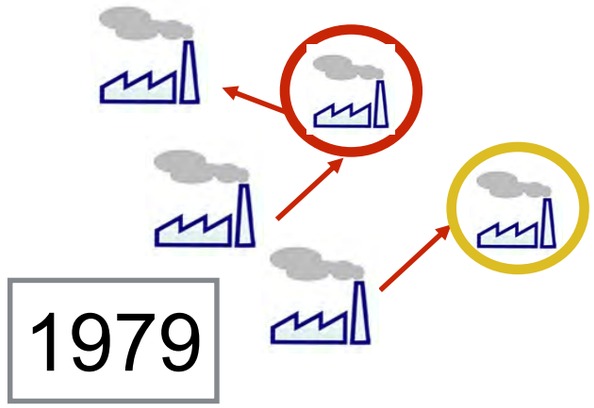
Facilitated collaborations by ENEA

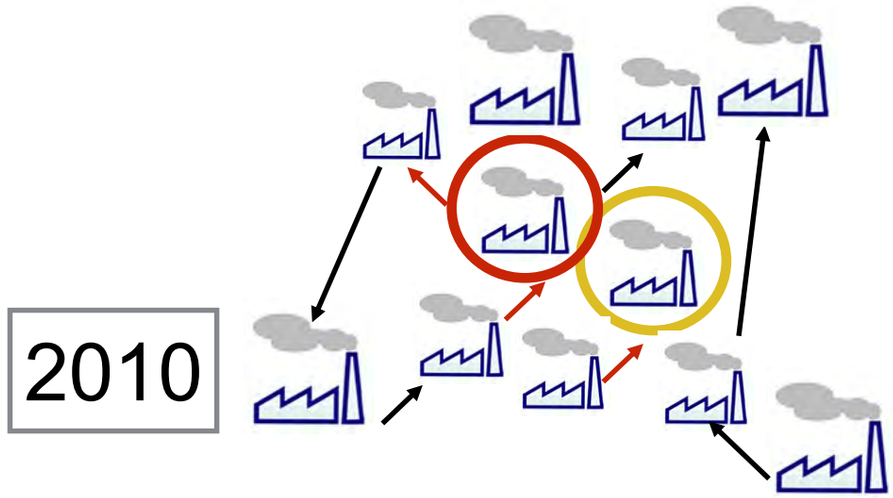
- In regions Emilia Romagna and Umbria for reuse of agricultural wastes and byproducts, average numbers greater than 43 km, and also transfers in longer distances in Sicily (such as 100 km) are reported.

Individual connections (bottom-up approach) between two or a few industries in Brescia

- Definitely shorter paths such as 25-30 km.

Possibility of following scenarios for evolution of the network based on a comparative approach (considering existing IS examples)





X. Zhang, L. Chai (2019). Structural features and evolutionary mechanisms of industrial symbiosis networks: Comparable analyses of two different cases. Journal of Cleaner Production 213 (2019) 528-539

Other considerations about the evolution of the shape of network

"Norms emerge and persist within closed network structures and innovativeness is better supported in more open networks which implies that the emergence of norms and increased innovativeness could not occur simultaneously" (Hatefipour, 2012).

Hatefipour, S. (2012). Facilitation of Industrial Symbiosis Development in a Swedish Region, Linköping University: Sweden

SNA Parameters

An industrial symbiosis network model G = (N, L), is provided for collaborations in an industrial district of Brescia. It is defined by two series of N and L parameters. N represents m nodes $N=(n_1;n_2;n_3\ldots;n_{i),\ (}i=1;2;3\ldots;m)$ which denote the firms inside the industrial district while L $=(l_{12};l_{13};l_{23}\ldots l_{ij),\ (i,j=\ 1,\ 2,\ 3,\ \ldots,\ m)}$ represents the relations between the companies.

- Average shortest path length

$$L = \frac{1}{N(N-1)} \sum d_{ij}$$

- Density

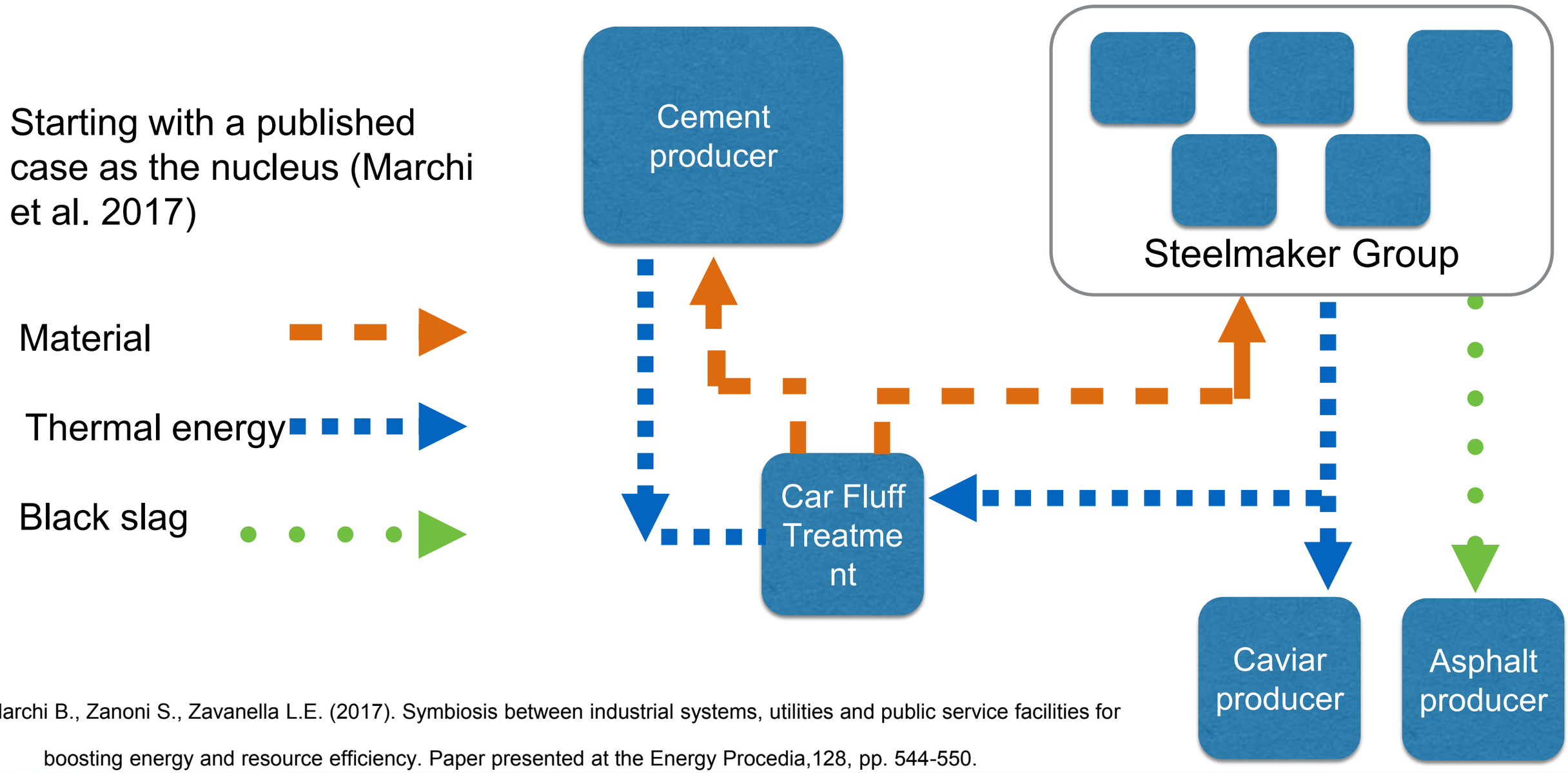
$$D = \frac{\sum L_w}{N \times (N-1)}$$

- Betweenness Centrality

$$BC_i = \frac{2 \times \sum_{j \le k} \frac{g_{jk(i)}}{g_{jk}}}{(N-1)(N-2)},\ i \neq j \& k$$

The proposed flow-diagram

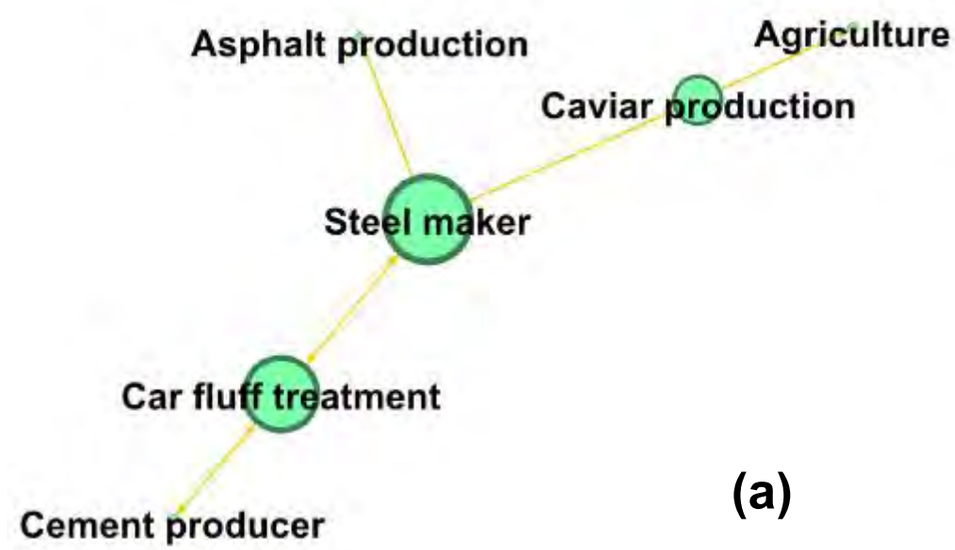
Starting with a published case as the nucleus (Marchi et al. 2017)



Marchi B., Zanoni S., Zavanella L.E. (2017). Symbiosis between industrial systems, utilities and public service facilities for boosting energy and resource efficiency. Paper presented at the Energy Procedia,128, pp. 544-550.

Step1:

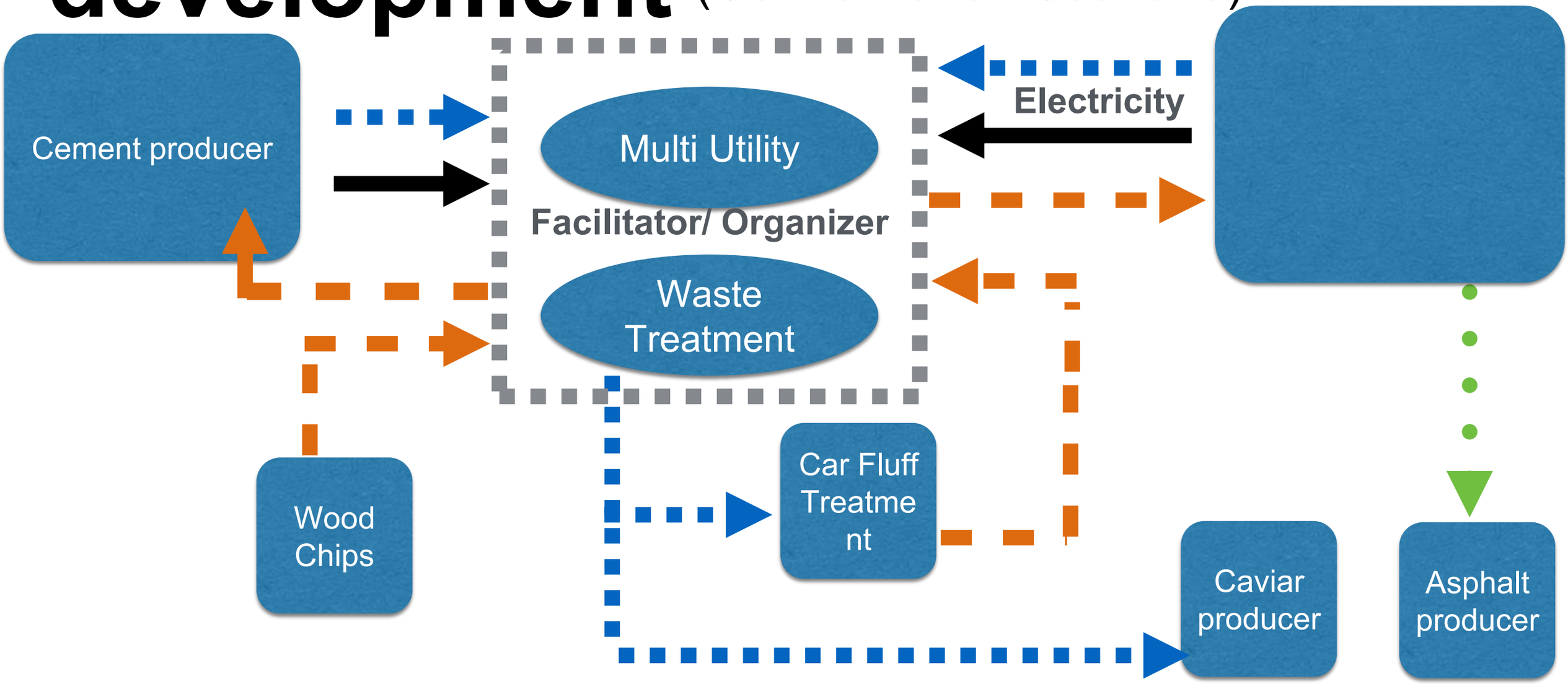
Network analysis with a collaboration mainly on waste with a few possibility for heat reuse



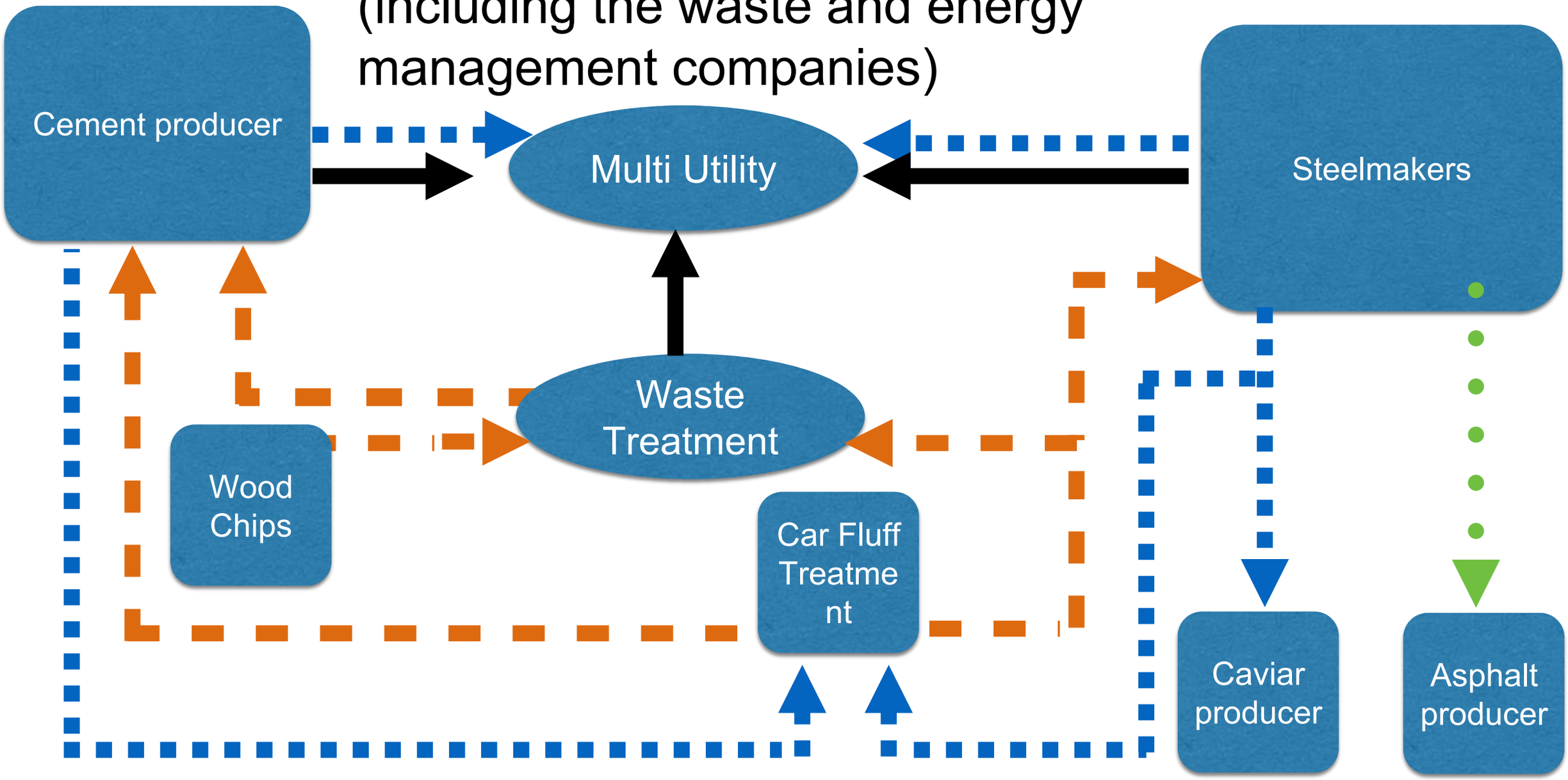
(a)

	number of nodes (nn)	number of edges (ne)	APL	AvCC	D	Network Diameter (ND)
a	6	7	1.875	0	0.233	4

Choosing the approach for development (Centralization Scenario)



De-centralization scenario
(including the waste and energy management companies)

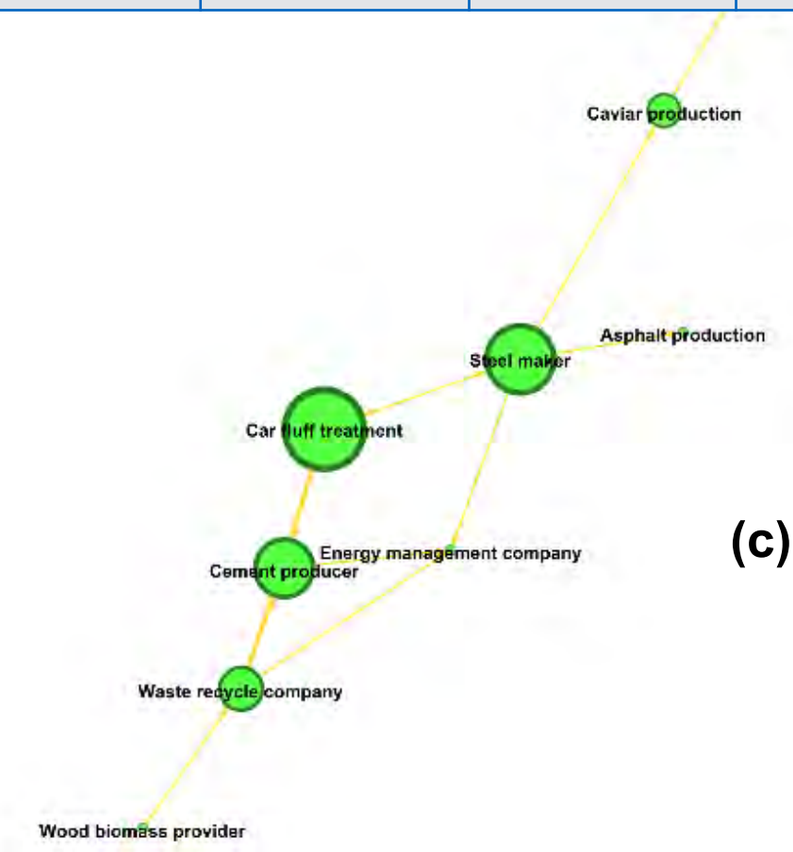


Step 2:

Comparison of the two approaches

	number of nodes (nn)	number of edges (ne)	APL	AvCC	D	Network Diameter (ND)
b	8	12	1.960	0	0.214	3
c	9	15	2.351	0.085	0.208	6

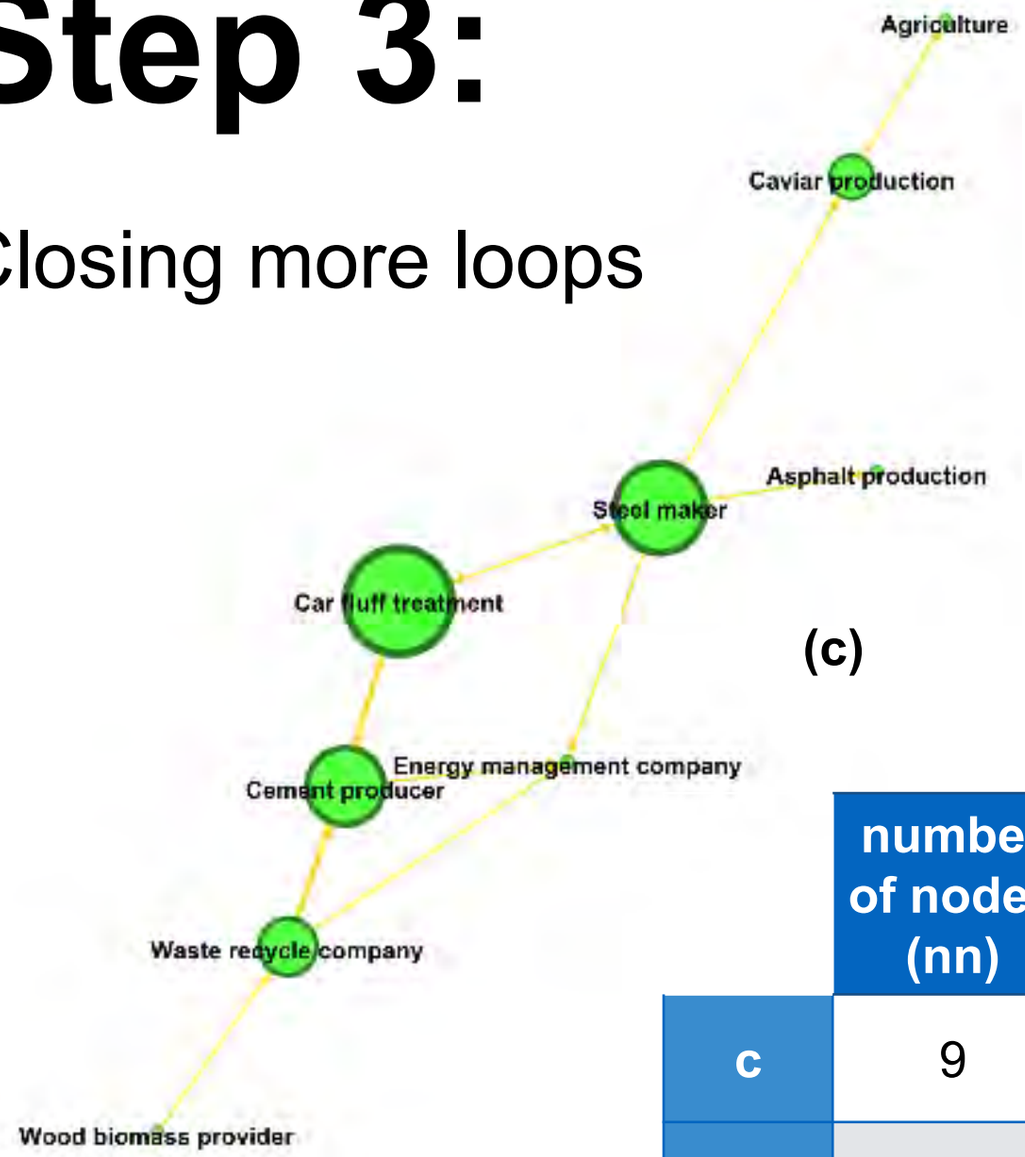
(b)



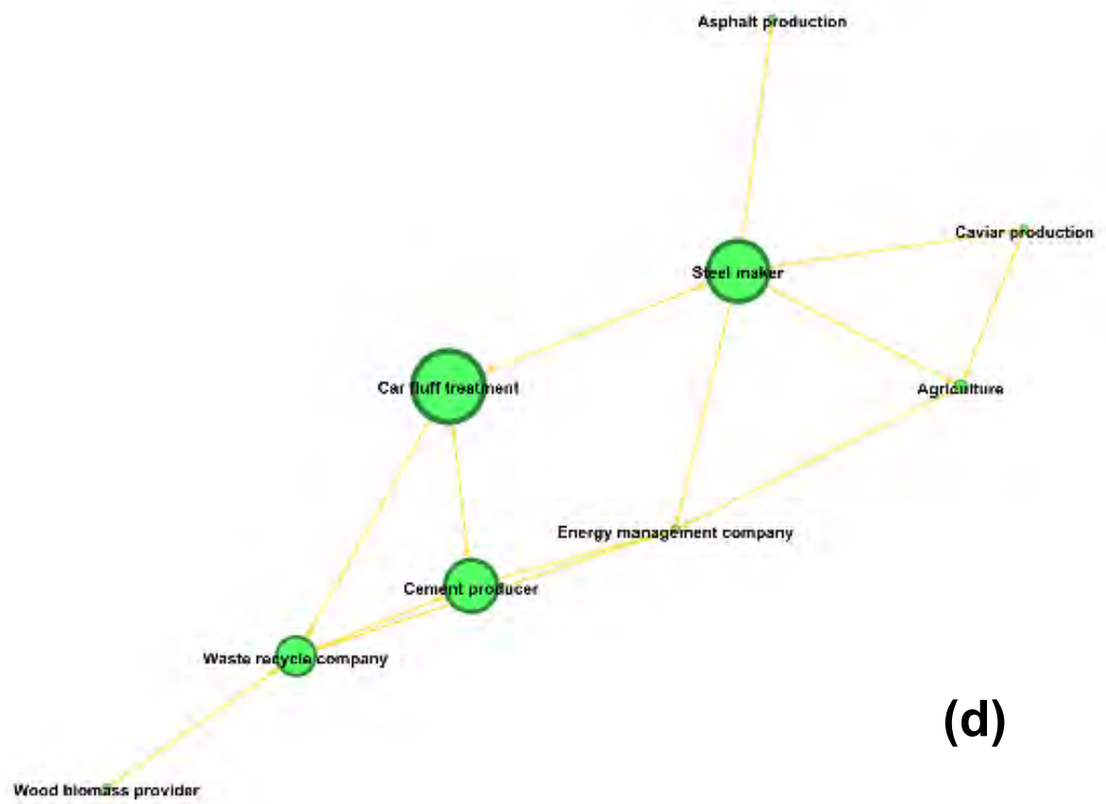
(c)

Step 3:

Closing more loops



(c)

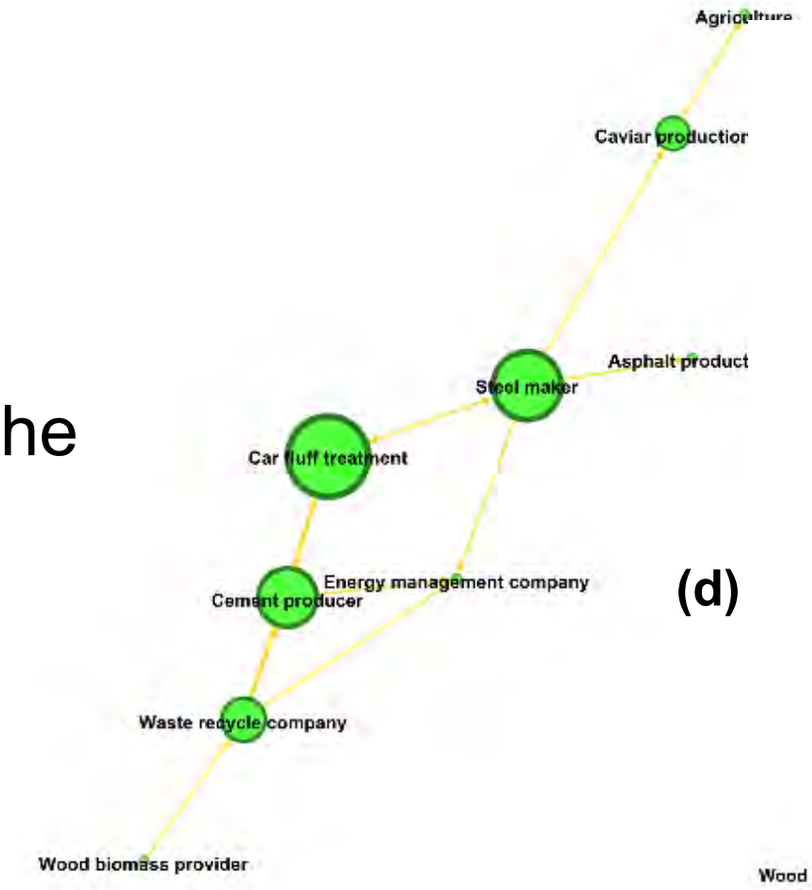


(d)

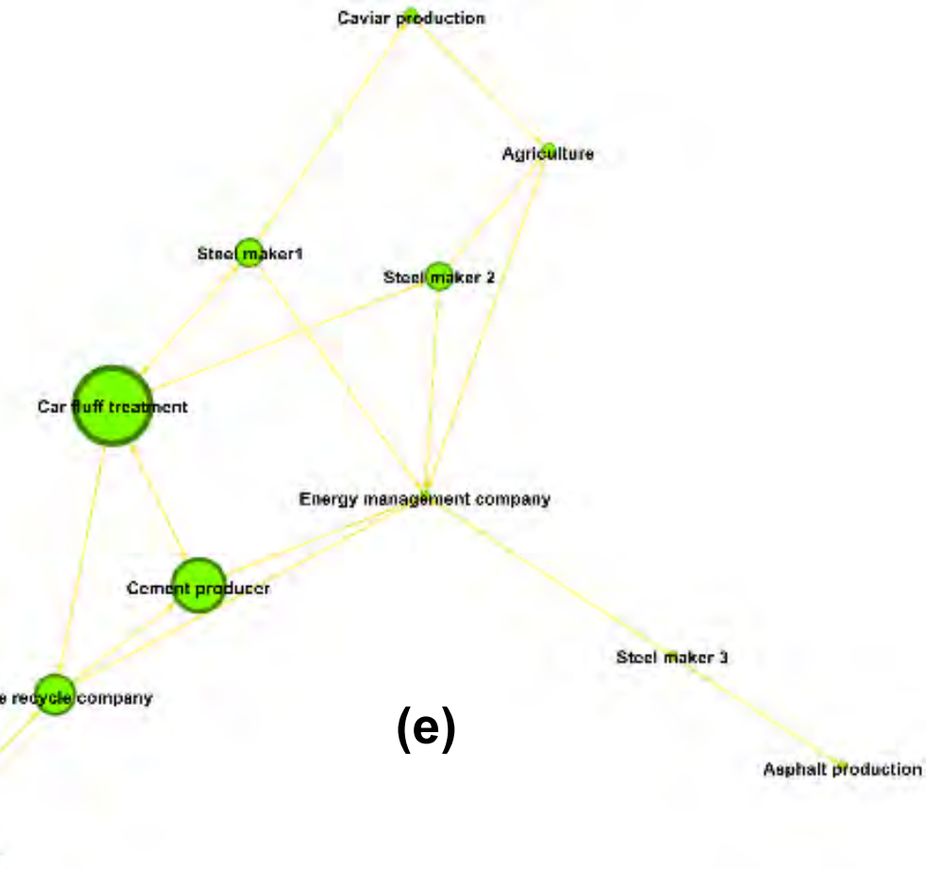
	number of nodes (nn)	number of edges (ne)	APL	AvCC	D	Network Diameter (ND)
c	9	15	2.351	0.085	0.208	6
d	9	17	2.179	0.193	0.236	5

Step 4:

Introduction of more players to the network



(d)

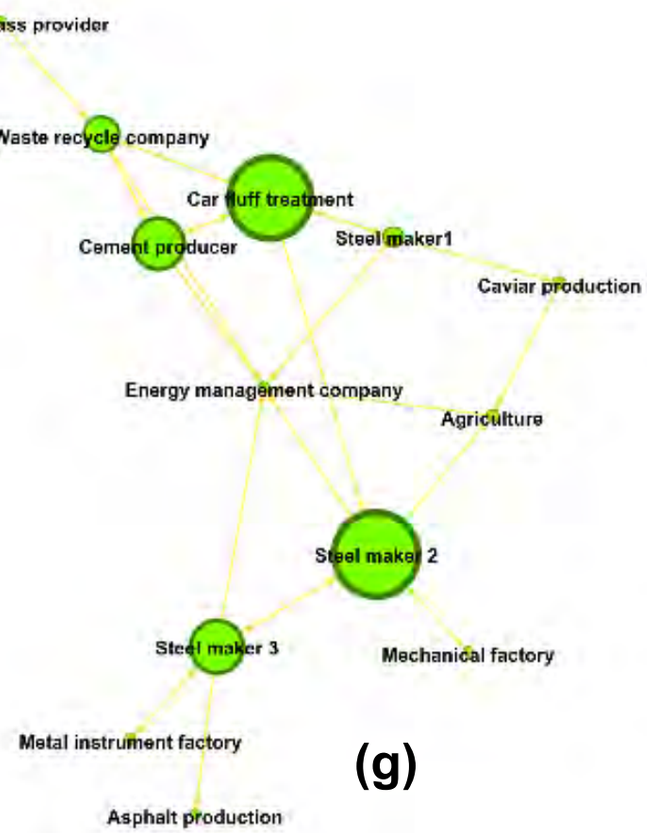


(e)

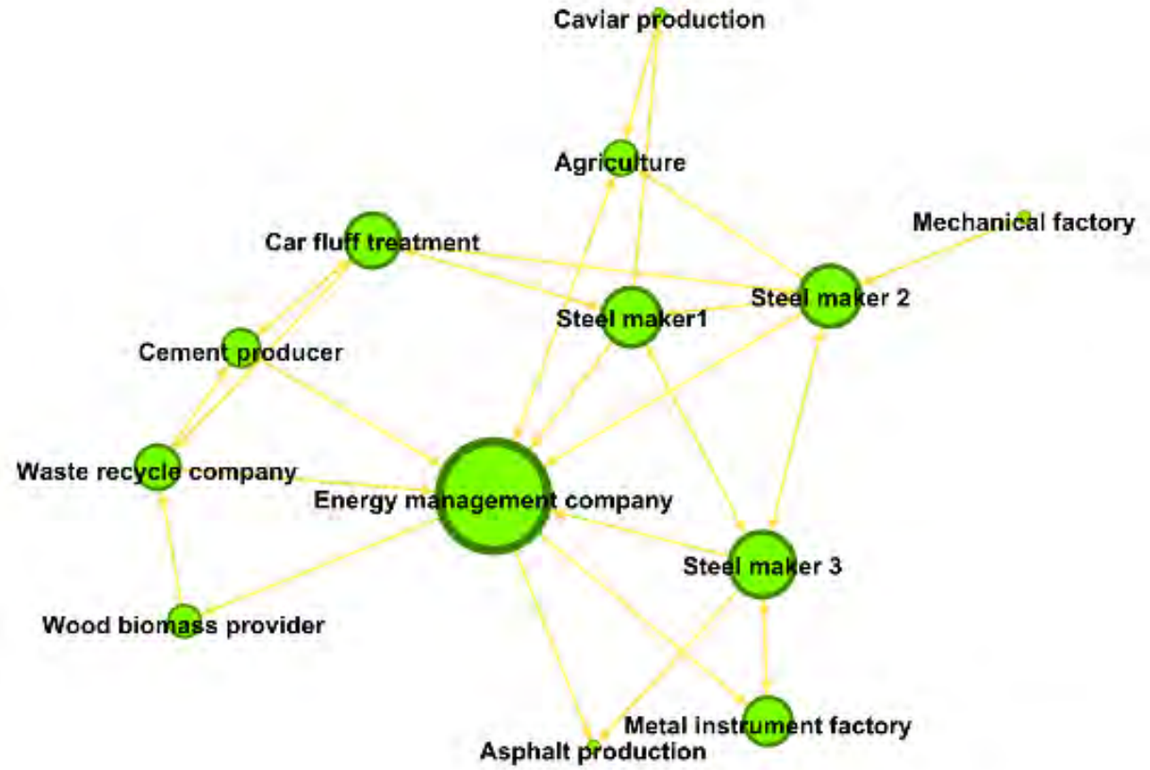
	number of nodes (nn)	number of edges (ne)	APL	AvCC	D	Network Diameter (ND)
d	9	17	2.179	0.193	0.236	5
e	11	21	2.023	0.087	0.191	5

Step 5:

Comparison of two models for reuse of energy inside the network for supporting weaker players or sending it outward (Formation of a reliable point of contact without centralization)



(g)



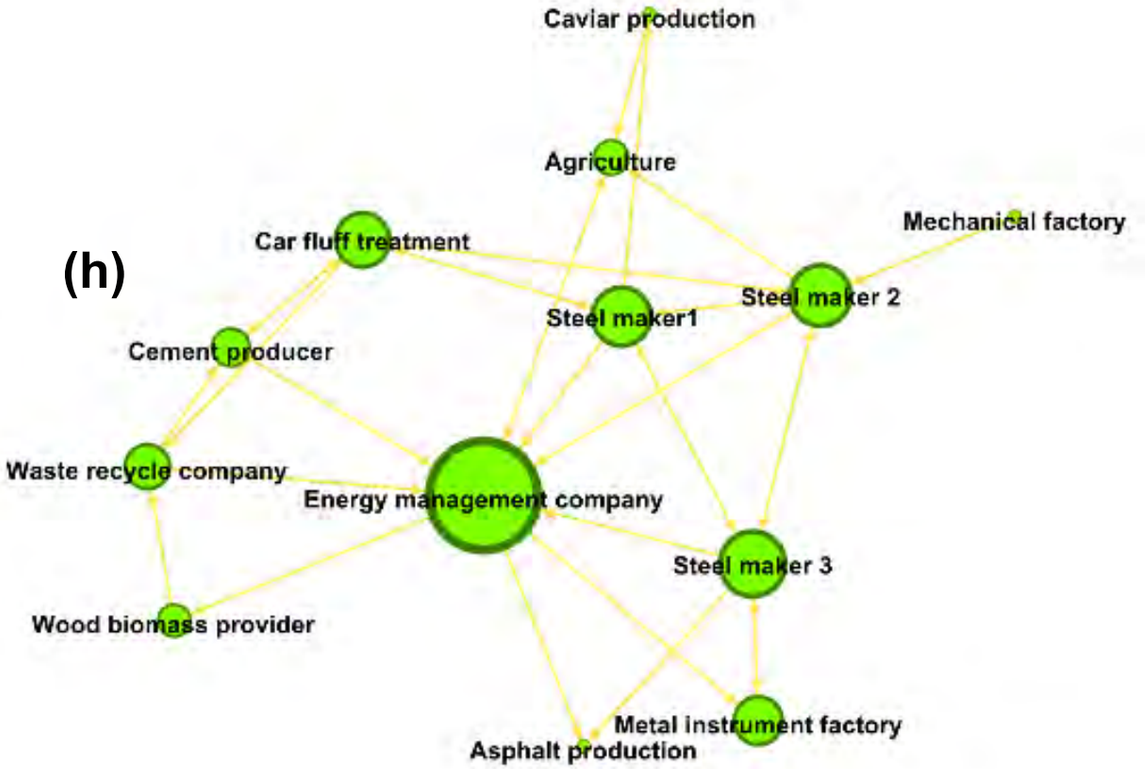
(h)

	nn	ne	APL	AvCC	D	N.D.
g	13	27	2.446	0.081	0.173	6
h	13	35	2.023	0.087	0.191	6

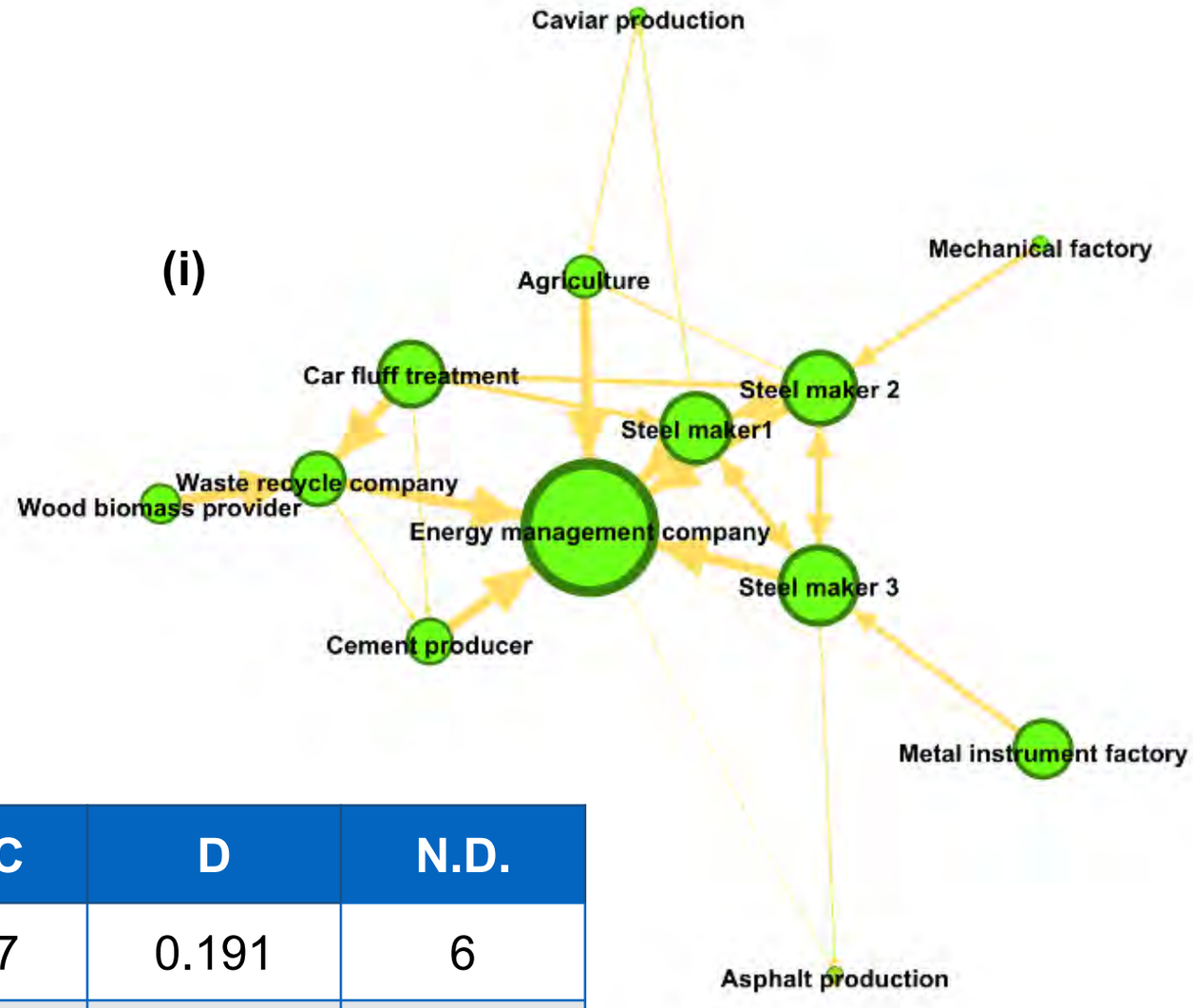
Step 6:

Giving weight to different sort of relations based on the contribution given to the total costs of the receiver industry (Wilting and Hanemaaijer 2014)

(h)



(i)



	nn	ne	APL	AvCC	D	N.D.
h	13	35	2.023	0.087	0.191	6
i	13	35	2.479	0.272	0.224	6

Conclusions

- In the SNA analyses, we considered the role of agriculture and municipality as stakeholders with a limited share which applies for a wider scope of IS collaborations.

- Starting by considering the collaborations (edges) of the same weights, it was attempted at the end to make the scenarios much closer to the actual social relations by giving special weights to each type of the edges (not only by the quality of collaborations but also by their quantity)

- The lack of a standard definition of proportional weights for symbiotic relations limits the application of this method.

- However it can provide the possibility of doing a multi-criteria analysis (e.g. considering the environmental benefit measurements along with economic savings as edges with different weights).

- Addition of more players to the network is possible.

Thank You!

"Industrial symbiosis scenarios for the province of Brescia"
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