The transition towards a bio-based economy: a social network analysis

Enrica Imbert♦, Luana Ladu♣, Almona Tani[1], Piergiuseppe Morone♦*

♦ Unitelma-Sapienza, University of Rome, Viale Regina Elena, 295 – 00161 Rome, Italy
♣ Technische Universitaet Berlin, Strasse des 17 Juni 135 – 10623 Berlin, Germany
**Dept. MEMOTEF, Sapienza University of Rome, Via del Castro Laurenziano, 9 – 00161 Rome, Italy*

Abstract: The consumption of plastics in Europe is considerable, equalling 58 million tonnes annually, at the same time the bio-waste generated annually across the EU ranges between 118 and 138 million tonnes, this representing a sizeable amount of potential feedstocks to be used in the production of bioplastic. Bearing this in mind, this paper focuses on the development of a bioplastics innovation niche, as an important sector of the bio-based economy and a viable solution to promote sustainable long-term growth. We look in a comparative perspective, at Italy and Germany. Relying on the Strategic Niche Management framework, the following niche mechanisms are analysed: (1) convergence of expectations, (2) learning processes and (3) networking activities with powerful actors. This is all more interesting considering that Germany and Italy implement divergent policies in support of the bioplastics industry. The comparative perspective has brought some interesting insights both on the maturity level of the two respective niches as well as on the emerging architectural properties of the underling social networks. Core findings show a general high level of expectations with respect to the future development of the bioplastic sector. Moreover, in both countries key elements undermining the niche development refer either to lack of policy support or to the changing and unstable institutional and regulatory framework. Technical knowledge and work force qualifications, on the contrary, are not conceived as a real threat to the niche development. When considering the network architecture of the two niches we found that the Italian network of actors was largely characterised by an active exchange of knowledge among firms, though the network was highly stratified and centralised. This last finding also emerged in the German knowledge exchange network, which however was characterised by the presence of several institutional actors actively participating in knowledge flows. These results related, in the authors view, to the different policy strategies followed by national governments in the two countries: the German case being characterised by large public investments in R&D, whereas the Italian case mostly characterised by demand side policy which effectively created a market for bioplastic shoppers.

Keywords: socio-technical transition, multi-level perspective, bio-based plastics, social network analysis, comparative assessment

[1] Presenting author; email: almona.tani@uniroma1.it; tel.: +39 348 326 3149

1. Introduction

The global population growth, coupled with current mass production and consumption models are putting under pressure the availability of global resources needed to fuel long-term growth. As pointed out by several scholars, current socio-economic challenges demand for a radical change in consumption habits (Spaargaren, 2011; Seyfang, 2009) and in the production system (Maxwell and van der Vorst, 2003) through the development of innovative and sustainable technologies. New technologies could indeed facilitate the transition from a society based on fossil fuel resources, mass consumption and inefficient waste management to one based on renewable resources and biomass, reduced consumption and reuse-oriented waste management (Morone, 2016).

Against this background, the bio-based economy has gained momentum in the transition literature as one of the primary paths through which this 'change of perspective' will occur. In this paper we focus particularly on the bioplastics industry, as an important sector of the bio-based economy for two fundamental, and substantially "quantitative", reasons: on the one hand, the consumption of plastics in Europe is considerable, equalling 58 million tonnes annually (Plastics Europe, 2016); on the other hand, the bio-waste generated annually across the EU ranges between 118 and 138 million tonnes, this representing a sizeable amount of potential feedstocks to be used in the production of bioplastic [COM/2010/0235 final].

Moreover, to date research has mainly focused on the technical aspects of waste management for bioplastics production; however, there are hardly any studies focusing on pathways of evolution from technological research and innovation to technological bioplastics niches maturation in European countries. Bearing this in mind, and building on Morone et al. (2015, which first addressed the Italian bioplastics technological niche), this paper provides a comparative assessment of the development of the bioplastics niches in Italy and Germany. Relying on the Strategic Niche Management framework, the following niche mechanisms are analysed: (1) convergence of expectations, (2) learning processes and (3) networking activities with powerful actors. This is all more interesting considering that Germany and Italy implement divergent policies in support of the bioplastics industry (Imbert et al., 2017). Hence, results obtained on the emerging architectural properties of the two niches will be linked, in a retrospective way, to the different policy strategies enacted by the respective national governments, this under the common umbrella of the EC policy for the bio-based economy.

In order to accomplish the goal of this paper, Social Network tools are applied to identify actors' interactions within each bioplastic niche and, through this, assess the niches' maturity for a socio-technical transition.

The remainder of the paper is structured as follows: Section 2 gives an overview of the theoretical background based on strategic niche management and innovation policy. Section 3 describes data collection and methods. Section 4 frames the case study and presents results in a comparative way. Section 5 links the findings of our survey to the countries' policy strategies and concludes the paper.

2. Theoretical framework

The transition to a more sustainable socio-economic and technological growth is a long and complex process, which involves the development of new technologies and the diffusion of new products in the market; this should entail, on the one hand, the social acceptance of new products, and on the other hand, a continuous demand for innovative sustainable technologies. With the current production system and consumption behaviour threatening continuously the environmental sustainability, there is a dire need to change direction and ground the prevailing economic system on renewable resources and biomass. The adoption of a bio-based economy marks a fundamental step in the direction of a sustainable transition, as it is based on green technologies that use renewable resources to produce a wide range of products (Imbert, 2017). However, it faces the many challenges of technical

development and dominant regime competition. Bioplastics, as part of the bio-based economy, provide a twofold sustainable answer: on the one hand, its production is based on biomass and not on fossil fuel feedstocks, and on the other hand, it can potentially use bio-waste that otherwise would have been landfilled. This requires the establishment of a circular economy where actors at all levels of the chain of production, consumption and end-of-life treatment, collaborate, network, and share knowledge.

In view of the fact that this sustainable innovation is generated as a synergy between academia, industry and government, the multi-level perspective (MLP) provides a valuable instrument to analyse the empowerment of the bioplastics technological niche (Smith and Raven, 2012) toward the establishment of a bio-based economy. The role and interactions of the actors at all levels define the internal forces and the external pressure capable to destabilize the current socio-technical regime (Geels, 2002) based on fossil fuel feedstocks for plastics production.

Since bioplastics production is at a niche level trying to take advantage of windows of opportunity in order to establish itself as a sustainably innovative regime, we have adopted the Strategic Niche Management framework in order to analyse the level of maturity and the structure of the network of the bioplastics niche. Following this theoretical approach, the presence of this technological niche is grounded on three crucial mechanisms; i) convergence of expectations towards a common view on the success of radical (and incremental) innovations within technological niches for challenging the incumbent regime; ii) learning processes as crucial means for increasing formal and informal knowledge, boosting technology transfer and spreading the use of innovative technologies; iii) networking with powerful actors, which have resources to promote markets and infrastructures for new technologies. All this come down to the belief that "(*N)o single actor has sufficient resources on their own to coordinate responses to selection pressures, or build adaptive capacity*" (Smith et al., 2005, p. 1503).

The presence or absence of these three mechanisms determines not only the emergence of an innovative niche but also its level of maturity (empowerment) able to break through the incumbent socio-technical regime.

In a multi-level perspective, there are other two interconnected levels, in addition to the niche level and its maturation mechanism, that determine the success of a radical innovation and a path-breaking socio-technical transition. These are the regime and the landscape, which can either jeopardize or trigger the niche empowerment, but which, in any case, shape the formation and empowerment of a technological niche (Schot, 1992; Rip, 1992). For this reason, we think that policy initiatives, being part of the incumbent regime based on fossil fuel feedstocks and over-exploitation of natural resources, determine the structure of the bioplastics niche network and the key actors composing it.

Institutional change and policy intervention are the main guiding force towards the accomplishment of the decarbonisation process, which competes with traditional infrastructures and less expensive products better-known by the market (Hopkins and Lazonick, 2012). For this reason, the outcome of a transition towards a bio-based economy is very much determined by the type of policy strategy implemented and the way it takes form. Indeed, the policy strategy framework in Quitzow (2015) provides a list of criteria for the identification of different types of policy strategies, grounded on objectives, policy measures, the strategy process, and institutional capacities. From this framework two opposite policy strategies emerge: a bottom-up strategy characterized by grassroots pressure for the policy strategy, and a top-down strategy characterised by the involvement of a deliberate process by the bureaucracy. Build on Quitzow (2015), Imbert et al. (2017) identified these two (ideal) categories of policy strategies in a comparative case study, assessing the emergence of a bio-based economy in Germany and Italy. They pinpointed a bottom-up strategy in Italy, also defined as a demand-side policy, implemented with the law n. 28/2012, which was the result of a pressure applied from the private sector. On the other hand, a top-down strategy emerged in the German case, where the policy strategy was implemented by means of considerable public investment in R&D aimed at boosting research and

innovation activity, and stimulating, through a supply-side policy, the emerging bio-based German economy.

This analysis sets the theoretical ground for analysing how these two alternative policy tools have triggered the creation and development of the bioplastics niche in the two countries under scrutiny. We shall now address this research question in the remainder of this paper.

3. Empirical Strategy and Methodology

To compare the German and Italian bioplastics niches having in mind convergence of expectations, learning processes and networking activities, we carried out an investigation by means of both qualitative and quantitative methods, articulated into three main steps.

We started with a stakeholder analysis, reviewing academic and grey literature to identify most relevant actors involved both in the Italian and German bioplastics industry.

As a second step, we developed a questionnaire composed by three sections. The first section aimed at collecting general information about the firms involved in the bioplastics industry, with questions on their product specialization and the number of workers hired. By using a five-point Likert scale, the second part of the questionnaire was designed to gather data on firms' expectations on the future development of the bioplastics sector by focusing on current and future technologies and their environmental and economic sustainability. Furthermore, respondents were asked to point at the main challenges associated with the production of bioplastics. Three questions relating to patents, trademarks and R&D funding were also included. Lastly, the third part of the questionnaire collected data on four types of firms' networks: informal knowledge sharing, joint patent, patent licensing and workforce/researchers exchange. Along with sociometric data, seven questions investigated the presence of powerful actors in the networks.

In the third step of our analysis we coordinated two focus groups of stakeholders that provided a list of the five most relevant firms actually involved in the respective domestic markets and assessed the content validity of the questions. Focus groups were conducted respectively in Italian and German and were both composed of four members: a government representative, a research institution representative, an industry representative, and a trade organization representative. Each focus group was facilitated by an author of the paper.

As just mentioned, the final part of the questionnaire specifically targeted the networks analysis. Despite being a fast-growing sector, the bioplastics industry is still at an early stage of development in both countries, a fact which makes the acquisition of informal and formal knowledge through networks of relationships at the firm level (e.g. Imbert et al., 2017; Giuliani and Bell, 2005) a key element of investigation. The aim of the social network analysis was therefore to develop an ego-network of the firms involved in the bioplastics industry in each country so as to investigate the development of a bioplastics market from an industrial point of view (see Lechner and Dowling, 2003). We applied a Social Network Analysis (Wasserman and Faust, 1994; Scott, 2000) to control for the presence of informal knowledge exchange schemes and formal technology transfer both among firms and between firms and other external actors such as Universities and research centres, public administrations, service providing organization, and NGOs. Indeed, relationships with this type of actors play an important role in shaping the architectural properties of the emerging networks.

In each country, the questionnaire was initially submitted to five actors suggested by focus groups, applying a roster-recall method. For each of the firms pre-listed in the roster, the respondent firm had to indicate whether or not it had a relationship of a pre-defined type. In addition, respondents were asked to recall all other firms they had this type of relationship with (over the last five years) and add them to the list. Doing so, we compensated for the fact that not all local actors were pre-listed on the roster. Relationships with external actors was built by using a pre-ordered category-list of external

actors identified by the focus groups and "augmented" through the recall method. Through this methodology, we obtained: (A) for Italy - a network of 30 firms and 30 external actors; (B) for Germany - a network of 24 firms and 63 external actors.

We imported data as an adjacency matrix in Excel format and further imported it into the social network analysis software UCINET 6 (Borgatti et al., 2002), in order to visualize the networks and to calculate the measures most relevant for our analysis (i.e. density[2], inclusiveness[3], clustering coefficient[4], and the network centralisation[5]). The questionnaire was administered online using the Qualtrics platform between March and May 2017.

4. Case study and Results

4.1. Case studies selection

Almost 40% of the 49 million tonnes of European plastic material demand is concentrated in Germany and Italy (PlasticsEurope, 2016), with Germany playing the role of Europe's largest producer of plastic through its leading plastic industry (GTAI, 2016/2017). This contrast with the fact that both countries are EU Bio-based economy frontrunners, ranking, respectively, 1st and 2rd in terms of turnover and employment (Piotrowski et al., 2016). In 2016 both countries counted with a high production capacity for bioplastics/biopolymers, estimated respectively at 109,515 t for Germany and 150,000 t for Italy. The importance of the bioplastic industry in both countries motivates the selection of Germany and Italy as case studies for the empirical research of this paper.

4.2. Expectations, challenges, and innovation activity (Section I survey)

By merging information gathered in the first section of the questionnaire, it resulted that the German bioplastics industry is mostly composed of large firms (i.e. with more than 250 employees), while in Italy the industry is largely characterized by small and medium size enterprises.

Most of the Italian firms that participated in the survey are specialized in the production or commercialization of bio-based shoppers and bioplastic cutlery, whereas in Germany most of the participants are specialized in the production of intermediate bio-based materials and compounds.

As shown in Table 1, the majority of the participants in both countries believe that bioplastics will gradually replace traditional plastics. Nearly 60% of interviewed firms consider that current technologies allow the production of bioplastics in an economically efficient way, and 75% of interviewed firms believe that future technological development will allow an economically efficient production by 2030. Most of the participants consider that the production of bioplastics is already sustainable from an environmental point of view, and the few participants that do not consider the current production of bioplastics sustainable, believe that it will become sustainable by 2030. Moreover, in both countries the majority of participants believe that in 5 or 10 years there will be an acceleration of the bioplastic demand.

The second part of section I inquired about the main existing challenges (risks and uncertainties) that are hampering the development of the bioplastic sector. The position of the companies in this regard in not as homogenous as in the first part of Section I discussed above.

[2] Ratio of existing ties to all possible connections.
[3] The number of connected points expressed as a proportion of the total number of points.
[4] A measure of the degree to which actors (vertexes) in a network tend to cluster together.
[5] A network index that measures the degree of dispersion of all node centrality scores in a network from the maximum centrality score obtained in the network.

As shown in table 2, differences emerged both within-countries and between-countries. The lack of demand for bioplastics and the lack of investments in the industry are considered as constraints that might hamper the development of the market by only one third of the participants, mostly located in Germany. Moreover, the lack of regulation and of long-term supportive policies are considered in both countries a challenge that is hampering the development of the market. Also, the majority of the participants consider the competition from other products and/or companies another factor hampering the development of their markets. On the other hand, the majority of participants do not consider technological constraints as relevant to existing challenges associated with the production of bioplastics; also, the lack of qualified labour forces is not seen as a challenge by the majority of companies participating in the survey. Finally, the lack of government support has been indicated by some companies in Italy as a challenge.

Table 1. Companies' expectations of the future of bioplastics

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
Bioplastics will gradually replace traditional plastics		3 G	3I 2G	6 I 8 G	3 I 2 G
Current technologies allow the production of bioplastics in an economically efficient way	1 G	6 G 3 I	2 G	6 G 8 I	1 G
Future technological development will allow the production of bioplastics in an economically efficient way by 2030		1G	3 G 2 I	10 G 6 I	2 G 3 I
The production of bioplastics is sustainable from an environmental point of view		2 G 1 I	4 G	7 G 6 I	3 G 4 I
The production of bioplastics will become more sustainable from an environmental point of view by 2030			4 G	9 G 5 I	3 G 6 I

Table 2. Main challenges to the development of the bioplastics industry

	1	2	3	4	5
Lack of demand	2 I	4 G 3 I	3 G 2 I	4 G 2 I	1G 2 I
Lack of investment	1 G	3 G 3 I	5 G 4 I	6 G 1 I	2 G 1 I
Technological constraints		5 G 1 I	7 G 5 I	1 G 3 I	3 G 1 I
Lack of regulation	1 G	4 G	3 G 3 I	4 G 4 I	5 G 2 I
Lack of long-term supportive policies	1 G 1 I	1 G	2 G 4 I	8 G 4 I	4 G 2 I
Dominant market share held by competitors	1 G 1 I	3G 2 I	4 G 4 I	7 G 2 I	2 G 1 I
Strong competition on product quality, reputation or brand	1 G 1 I	3 G 1 I	7 G 2 I	4 G 4 I	2 G 2 I
Lack of qualified labor	6 G	4 G 3 I	5 G 2 I	2 G 3 I	1 I

As mentioned in Section 2, the second part of the survey was aimed to reconstruct the web of social relations among firms producing bioplastic. This network would represent the core of the overall reticular structure, which encompasses – through an egocentric network approach – 'external' links with institutions and other stakeholders including research institutions, government bodies, NGOs, and waste related entities. The analytical framework described in Section 2 guides the identification and understating of the relationship between egocentric network properties and the trajectory of the bio-based niche development in Italy and Germany.

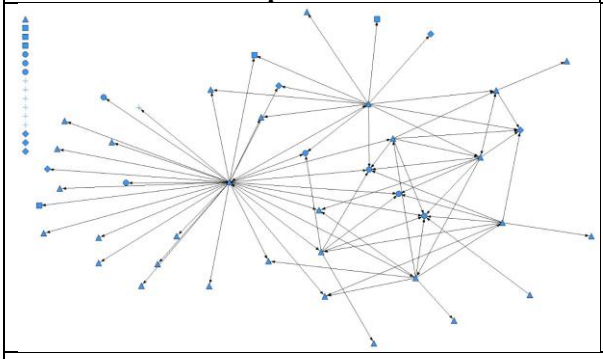
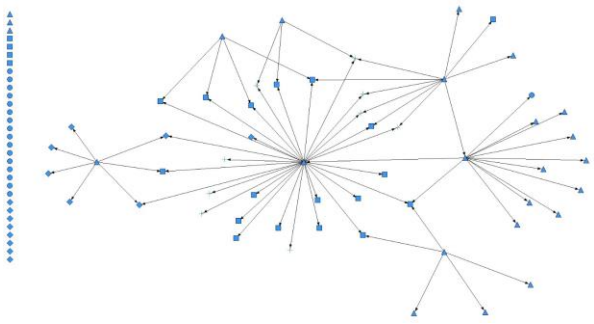
4.3. The social network analysis of bioplastics niches in Italy and Germany (Section II survey)

The Social Network Analysis elaborated with UCINET6.0 was based on four networks for each country – i.e. (1) sharing of informal knowledge, (2) development of joint patents, (3) patent licensing, and (4) staff or researchers exchange. One overall outcome of this analysis, which applies both to Italy and Germany, is the density ranking across the four networks' typologies. The network of informal knowledge share is the densest one; the staff/researchers exchange network ranks second, and, finally, the joint patent and patent licensing networks are highly disconnected in Italy and do not exist at all in Germany.

4.3.1. Informal knowledge

When looking closely at the informal knowledge networks, we can observe the presence of a single component in both cases with few disconnected actors, reflecting an inclusiveness degree equal to 73.3% in Italy and to 64.4% in Germany. Moreover, both networks display a large number of peripheral actors connected to few central nodes. This reflects in the generally low density of the two systems equal to 2.3% in the Italian case and to just 0.9% in the German case.

Comparing Fig. 1a and Fig. 1b, the most striking result emerging with respect to informal knowledge networks is their composition in terms of actors' typologies. In the Italian case, most of the existing links connect firms involved in the production of bioplastics. Few additional links bring into the network a handful of service firms, research institutions, and NGOs. This, as opposed to the German network where a much higher number of public institutions, research institutes and NGOs populate the informal knowledge sharing network. The higher heterogeneity of actors' typology in the German niche may be explained by the vigorous policy intervention put into place by the German government in terms of public R&D expenditure, thus bringing public actors into the bioplastics niche. This was not the case in Italy, where most of the government initiatives were concentrated on the demand side, boosting the market uptake of bioplastic shoppers (e.g. Morone et al., 2015; Imbert et al., 2017).

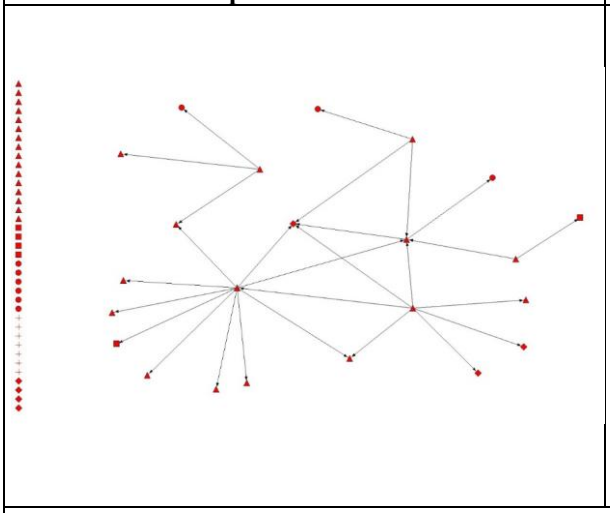
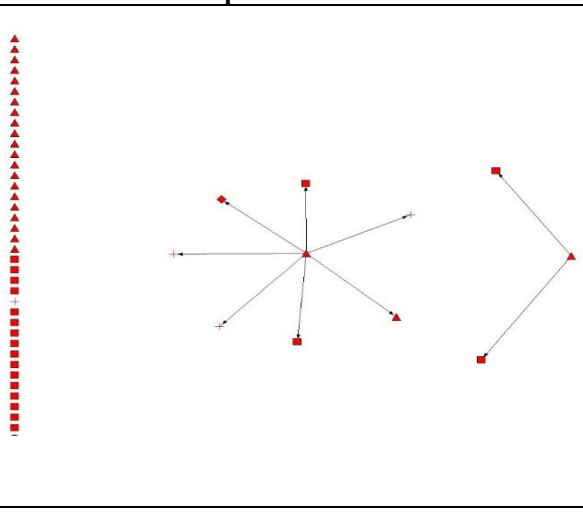
Fig. 1a Informal knowledge network in the Italian bioplastics network	**Fig. 1b Informal knowledge network in the German bioplastics network**
	
Note: *Triangles = firms; rectangles = research institutes/universities; plus = public institutions, circles = service firms; diamonds = NGOs/associations*	

Also the clustering coefficient of the Italian informal knowledge network is higher when compared to the German case – the two coefficients equalling respectively 0.401 and 0.008. This property of the two networks stems from their highly centralised structure, which in the German case shows a network relying on just four actors connecting nearly 80% of non-isolated nodes.

Overall, the emerging properties of these two networks reflect the presence of a few powerful actors, who benefit from unequally distributed advantages. For instance, as reported by firms involved in the survey, in the Italian bioplastics niche there is one particular powerful actor in terms of technological development, financial resources mobilization, and influence in the public policy initiatives. In the German case on the other hand this role is covered by four actors sharing central power in the emerging bioplastics niche.

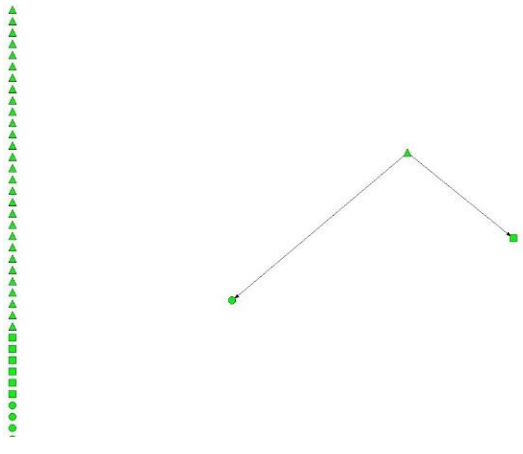
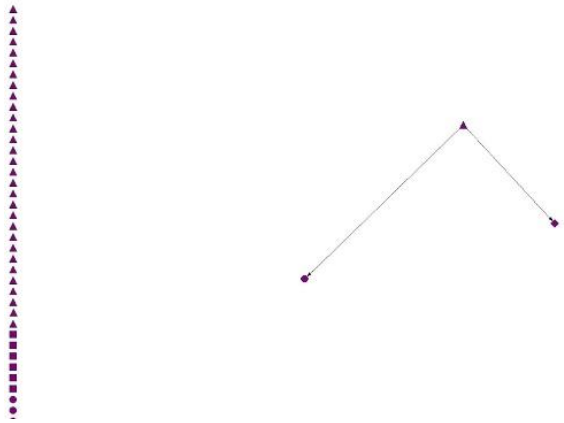
4.3.2. Staff/researchers exchange

The staff exchange networks are less dense than the informal knowledge network, equalling 0.8% of density in the Italian bioplastics industry and 0.1% in the German one. The Italian network is clustered in one single component including 26% of the actors, whereas the German network is clustered in two components with the principal component including less than 10% of the total number of actors. Like in the informal knowledge network, in the staff exchange network in Italy the main actors are firms and some service-providing firms, while in Germany this network is composed of public institutions, as well as research institutes in addition to bioplastics production firms. The heterogeneity of actors involved in the staff exchange network shows also a high mobility of employees from the public to the private sector and/or vice versa and from research institutes to private firms and/or vice versa. Also in these two networks, the presence of central powerful actors is notable and, similarly to the informal knowledge network, central actors are bioplastics producers.

Fig. 3a Staff exchange network in the Italian bioplastics network	**Fig. 3b Staff exchange network in the German bioplastics network**
	
Note: *Triangles = firms; rectangles = research institutes/universities; plus = public institutions, circles = service firms; diamonds = NGOs/associations*	

4.3.3. Joint patent and patent licensing

More formal networks, such as joint patent development and patent licensing, are way underdeveloped in Italy and do not exist in the German bioplastics niche. As showed in figures 4 and 5, these two networks in Italy are at an embryonic stage with just three actors involved in joint patents or patent licencing.

Fig. 4 Joint patent network in the Italian bioplastics network	Fig. 5 Patent Licensing network in the Italian bioplastics network
	
Note: *Triangles = firms; rectangles = research institutes/universities; plus = public institutions, circles = service firms; diamonds = NGOs/associations*	

5. Discussion and Conclusions

The comparative perspective on the bioplastic niche proposed in this paper has brought some interesting insights both on the maturity level of the two respective niches as well as on the emerging architectural properties of the underling social networks. These findings can well be linked to earlier results obtained by means of a comparative assessment of the main policy measures undertaken in both countries (Imbert et al., 2017).

In a nutshell, our findings show a general high level of expectations with respect to the future development of the bioplastic sector. Moreover, in both countries key elements undermining the niche development refer either to lack of policy support or to the changing and unstable institutional and regulatory framework. Technical knowledge and work force qualifications, on the contrary, are not conceived as a real threat to the niche development.

When considering the networking structure of the niche, some interesting similarities and differences emerged through the comparative exercise. The Italian network of actors was largely characterised by an active exchange of knowledge among firms, though the network was highly stratified and centralised, with very few actors with a central position. This finding also emerged in the German knowledge exchange network, which however was characterised by the presence of several institutional actors actively participating in knowledge flows. As discussed in Section 4, this finding is related, in the authors view, to the different policy strategies followed by national governments in the two countries: the German case being characterised by large public investments in R&D, whereas the Italian case mostly characterised by demand side policy which effectively created a market for bioplastic shoppers. The anaemic staff exchange and the complete lack of joint patent and patent licensing in the German case is most likely associated with the large size of firms operating in the sector. A fact which is less dominant in the Italian context.

Far from being conclusive, this preliminary study brings to the surface a fertile environment for the niche development process, which however still needs external support on its way to maturity. Perhaps, Italy and Germany could learn from each other's experiences: with the Italian niche needing to be more inclusive with respect to institutional actors, research centres and NGOs, and the German niche needing to further stimulate informal knowledge sharing beyond the core group of central actors dominating its network' structure.

References

Altenburg T., Pegels A., *Sustainability-oriented innovation systems - managing the green transformation*, Innovation and Development, 2 (1), 5-22 (2012)

Borgatti, S.P., Everett, M.G. and Freeman, L.C. (2002) *Ucinet 6 for Windows: Software for Social Network Analysis*, Analytic Technologies, Harvard, MA (2002)

Cantner U., Graf H., Herrmann J., Kalthaus M., *Inventor networks in renewable energies: The influence of the policy mix in Germany*, Research Policy, 45, 1165–1184 (2016)

European Commission, Communication from the Commission to the Council and the European Parliament on future steps in bio-waste management in the European Union {SEC(2010) 577}, http://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX:52010DC0235 (2010)

Geels F. W., *Technological transitions as evolutionary reconfiguration processes: a multi-level perspective and a case study*, Research Policy, 31 (2002)

Giuliani, E. and Bell, M., *The micro-determinants of meso-level learning and innovation: evidence from a Chilean wine cluster*, Research Policy 34, 47-68 (2005)

GTAI, 2016/2017, *The Plastic Industry in Germany*, Germany Trade and Invest

Hopkins M., Lazonick W., (2012) *Soaking up the sun and blowing in the wind: Renewable energy needs patient capital*, Airnet, Working Paper, Available online at http://www.theairnet.org/files/research/Hopkins/CleanTech_PatientCapital_20121129a.pdf

Imbert E., *Food waste valorization options: opportunities from the bioeconomy*, Open Agriculture, 2(1), pp. 195-204. Retrieved 31 May. 2017, from doi:10.1515/opag-2017-0020

Imbert, E., Morone, P., Bigi, F., *Assessing the potential of social enterprises through social network analysis: Evidence from Albania*, MPRA working papers, Available online at https://mpra.ub.uni-muenchen.de/78115

Lechner C., Dowling M., *Firm networks: external relationships as sources for the growth and competitiveness of entrepreneurial firms*, Entrepreneurship & Regional Development, 15 (1) (2003)

Maxwell. D., van der Vorst R., *Developing Sustainable Products and Services*, Journal of clear production (2003)

Mazzucato M., *The Entrepreneurial State: Debunking public vs. private sector myths*, Public Affairs, New York (2015)

Morone, P., *The times they are a-changing: Making the transition toward a sustainable economy*, Biofuels, Bioprod. Bioref. 10: 369–377 (2016)

Morone, P., Tartiu, V., Falcone, P., *Assessing the potential of biowaste for bioplastics production through social network analysis*, Journal of Cleaner Production 90(1), 43-54 (2015)

Plastics Europe, EPRO, *Plastics-The facts 2016: An analysis of European plastics production, demand and waste data*, http://www.plasticseurope.org/documents/document/20161014113313-plastics_the_facts_2016_final_version.pdf (2016)

Piotrowski, S., Carus, M., Carrez, D., *European Bioeconomy in Figures*, available at: http://biconsortium.eu/news/european-bioeconomy-eur-21-trillion-turnover-and-183-million-employees (2016)

Quitzow, R., *Assessing policy strategies for the promotion of environmental technologies: A review of India's National Solar Mission*. Reseach Policy 44, 233–243 (2015)

Rip A., Science and technology as dancing partners, Springer (1992)

Scott, J., *Social Network Analysis: a Handbook* (second ed.) Sage, London (2000)

Schot J., *Constructive Technology Assessment and Technology Dynamics: The Case of Clean Technologies*, Science, Technology & Human Values, 17 (1), 35-56 (1992)

Seyfang, G., *The New Economics of Sustainable Consumption: Seeds of Change*, Palgrave Macmillan, Basingstoke (2009)

Smith A., Raven R., *What is protective space? Reconsidering niches in transitions to sustainability*, Research Policy, 41, 1025-1036 (2012)

Smith A., Kern F., Raven R., Verhees B., *Spaces for sustainable innovation: Solar photovoltaic electricity in the UK*, Technological Forecasting & Social Change, 81, 115-130 (2014)

Spaargaren G., *Theories of practices: Agency, technology, and culture: Exploring the relevance of practice theories for the governance of sustainable consumption practices in the new world-order*, Global Environmental Change 21 (3), 813-822 (2011)

United Nations, *World Population Prospects: The 2015 Revision*, New York: United Nations (2015)

Veugelers, R., *Which policy instruments to induce clean innovating?* Research Policy, 41 (10), 1770-1778 (2012)

Wasserman, S., Faust, K., *Social Network Analysis. Methods and Applications*, Cambridge University Press (1994)