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Assessing the potential of biowaste for bioplastics production through social network analysis

Piergiuseppe Morone [a, *], Valentina Elena Tartiu [b], Pasquale Falcone [c]

[a] Department of Law and Economics, Unitelma-Sapienza University of Rome, Italy
[b] Institute of Systems Sciences, Innovation and Sustainability Research, University of Graz, Austria
[c] Department of Law, Philosophy and Economic Studies, Sapienza University of Rome, Italy

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ABSTRACT

The growing global population, matched with constraints imposed by the natural resources' system, entails either productivity growth (i.e., making more output with the same input) or developing new uses for waste (i.e., finding new sources of inputs among unused outputs). Biowaste emerged as a resource with a significant potential to be employed as a raw material for the production of chemicals, materials and fuels given its abundant volumes generated globally. This study aims at providing insights into the potential development of the bioplastics technological niche that uses secondary feedstock (biowaste) instead of dedicated crops and into the factors that may hinder the full development of this niche. Specifically, looking at the Italian bioplastics market, the following three research questions are addressed: (1) What are the structural characteristics of the Italian bioplastics network? (2) What is the social network architecture? (3) How does the network architecture affect the potential development of the bioplastics technological niche that uses a secondary feedstock? The empirical investigation provides evidence that the architectural structure of the Italian bioplastics producers network offers great opportunities for the development of a technological niche based on biowaste valorization. However, the system has shown to be weak especially as far as expectations are concerned, as these are generally low and, more critically, are low for those actors occupying central positions in the network. This shortcoming could jeopardize the niche development process, if no appropriate policy actions are undertaken. More specifically, this study could support decision makers in developing specific strategies to unlock the enormous potential of biowaste as well of the bioplastics sector by: (i) empowering knowledge creation and its diffusion and by (ii) supporting strategic collaboration schemes. For instance, policy measures could be introduced to the possibility to stimulate social learning as a driver of expectations. Finally, although this study addresses a single case study, the proposed methodology and the specific findings may pave the way for further investigations that consider stakeholders' behavior and what is needed in order to mobilize them to embark on bioplastics production projects on a commercial scale.

1. Introduction

Approximately 120–140 million tons of biowaste are produced every year solely in the EU, and approximately 40% of this entire amount is stored in landfills – up to 100% in some member states (EU, 2011), such as Bulgaria, Romania, Latvia, Greece, Lithuania, Czech Republic (EEA, 2013).

With global climate change challenges and its various effects on ecosystems and on resource depletion, the issue of biowaste and its diversion from landfills has captured the attention of governments, environmental and social organizations, businesses and academics, becoming an increasingly urgent priority. This is reflected in the relatively abundant literature targeting various aspects associated with biowaste management.[1] Across the world, the most used practices to treat urban biowaste are anaerobic digestion and composting, allowing the biowaste to be reused (completely or partially) at the end

[1] See, for instance: Arcadis and Eunomia (2009), addressing options to improve the management of biowaste; Dermibas et al. (2011), considering the conversion of biowaste to synthetic fuels; Fava et al. (2015), investigating the issue of biowaste biorefinery; and Mirabella et al. (2014), Lleó et al. (2013), and Galanakis (2012), considering valorization pathways.

* Corresponding author.
E-mail address: piergiuseppe.morone@unitelma.it (P. Morone).

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of the treatment process (D'Hondt and Voorspoels, 2012). However, these techniques lead to low-value products despite the possibility of using more advanced technologies (through the identification and isolation of valuable components present in the biowaste streams) that could potentially recover higher-value products for use in chemical, agriculture, pharmaceutical or other industries (in support of this idea, the recent studies by Runge et al. (2012) and Montoneri et al. (2011) can be mentioned). Therefore, the focus should shift towards finding better means to exploit this valuable feedstock, which is largely unavoidable.

To date, the majority of research studies have focused on the technological aspects of biowaste valorization, reporting case studies and/or pilot-scale laboratory experiences (a review of this research is provided in Arancon et al., 2013; Liguori et al., 2013). This calls for a further understanding of how new biowaste technological pathways (validated mainly on a laboratory scale and sometimes on the pilot scale) can develop and contribute to the evolution of a mature technological niche. This area of enquiry is still under investigated, and its applications are under appreciated, both from a theoretical point of view and from an industrial-application perspective.

This paper aims to address this gap, focusing on the potential of biowaste as a feedstock for bioplastics production. More specifically, the paper investigates the Italian bioplastics sector,[2] assessing its potential to develop into a mature technological niche. Hence, in our investigation, we consider fossil-fuel production technology as the dominant technological regime and the bioplastics that use biowaste as feedstock as the most viable emerging technological niche.

An new approach for assessing the development of a niche is to look at its network (Hermans et al., 2013: 613), as "networks are capable of revealing the structure that underpins relationships between stakeholders" (Nugroho and Saritas, 2009: 21), also highlighting emergent effects that cannot be revealed using other methods (Wasserman and Faust, 1994; Scott, 2000; Knox et al., 2006; Nugroho and Saritas, 2009). The fact that network structures play a key role in explaining the diffusion potential of emerging technologies is increasingly acknowledged (Hermans et al., 2013: 613).

Building on this assumption, we assess the potential development of the bioplastics niche employing social network tools within the framework of strategic niche management. Specifically, we focus on three key niche mechanisms: (1) expectations, (2) learning processes and (3) network formation (see Kemp et al., 1998; Lopolito et al., 2011).

Hence, we concentrate on three main research questions, namely: (1) What are the structural characteristics of the Italian bioplastics network? (2) What is the social network architecture? (i.e., Is the network characterized by one or more star agents? What is its degree of connectivity?) (3) How does the network architecture affect the formation of expectations and the learning processes related to the potential development of the bioplastics technological niche that uses a secondary feedstock?

Thus, through our research study, we aim to provide insights into the potential development of the bioplastics technological niche that uses a secondary feedstock (biowaste) instead of dedicated crops specially harvested for the bioplastics production (such as corn, rice, potatoes, barley, sorghum, sugar cane, beet, etc.) and seek insight into factors that may hinder the full development of such a technological niche. To the best of our knowledge, there has been no previous effort to address this issue; therefore, this study aims to contribute to covering this gap. In addition, this paper aims to illustrate the potential contribution of social network analysis (SNA) tools to technology foresight studies through a practical case study. Previous efforts using this method, as reported in the literature, are concentrated on methodological aspects of incorporating SNA into foresight studies (e.g., Nugroho and Saritas, 2009; Saritas and Nugroho, 2012).

The paper is structured as follows. In Section 2, bioplastics production in the context of the bioeconomy is briefly depicted. In Section 3, the methodological framework is explained. Section 4 is divided into two sections: in Section 4.1, the case study designed to investigate the development of the technological niche (i.e., bioplastics shopping bags derived from biowaste valorization) is outlined, and Section 4.2 presents the results. Section 5 links the findings of the research study to the literature review and outlines the research implications. Finally, the concluding remarks are highlighted in Section 6.

2. Bioplastics production in the context of the bioeconomy: a snapshot

In the context of the transition towards a bioeconomy (i.e., an economy in which sustainability and efficient use of resources are the core of industrial, business and social activities), bioplastics have drawn the attention of both decision makers and industries across the globe (Iles and Martin (2013) reported on new business models of the major chemical players for bioplastics production). As a matter of fact, globally, bioplastics represent the fastest-growing product line in the bio-based products industry (OECD, 2013: 11) (see Fig. 1).

The leading position of Asian countries (in particular China) in their bioplastics production capacity is hardly surprising if we consider their R&D share of basic, applied and development activities over the last decade (see Fig. 2).

However, the European Commission identified the bio-based products sector as of high societal and economic interest and identified bioplastics as a main driver for the achievement of the sustainable goals of EU 2020 (European Bioplastics, 2013: 1). The main challenge for EU countries lies in "the ability to reach demonstration scale of advanced biorefineries to mature technologies" (Carrez, 2013: 6) in order to be able to produce and commercialize high added value biobased products.

A recent OECD (2013) report argues that the bioplastics sector is deprived of coherent (supportive) policies, as "there is no international pattern of support for bioplastics, except that the niche

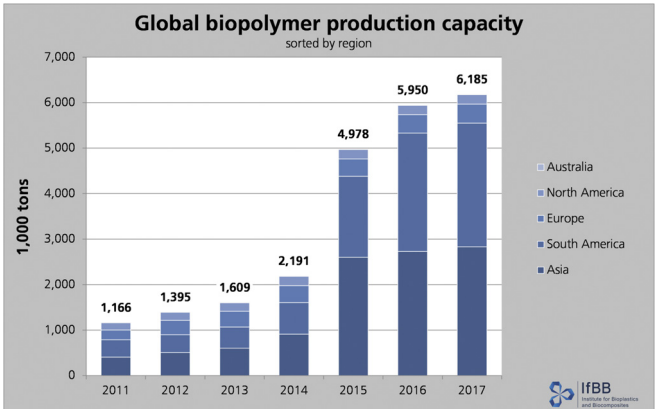

Fig. 1. Evolution of global biopolymer production capacity between 2011 and 2017. Source: IfBB, Institute for Bioplastics and Biocomposites (2013).

[2] Specifically, in order to have a common denominator across the firms interviewed, we analyze the bioplastics niche of shopping bag production. This choice is further explained in Section 3.