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Knowledge networks and their role in shaping the relations within the Agricultural Knowledge and Innovation System in the agroenergy sector. The case of biogas in Tuscany (Italy)

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ABSTRACT

This paper presents an analysis of the knowledge retrieval networks behind the adoption of farm biogas in an area of Mediterranean Europe featuring arable farming systems. The overarching objective of the analysis is to help and understand the interplay between biogas adopters and the stakeholders of the Agricultural Knowledge and Innovations System (AKIS). Specifically, the paper proposes an application of social network analysis that aims at bringing out the influence of knowledge exchanged within the system on adopters' business decisions, as well as adopters' contribution to knowledge upgrading. Social network analysis focuses on the estimation of three network attributes (cohesion, knowledge co-creation, and brokerage) using primary data, collected in 2015 via questionnaire to plant adopters. Self-education, upstream industry, agronomists, farmer/biogas unions, university, public-funded projects, and public research centers are AKIS' stakeholders, which adopters turn to when seeking for information and/or know-how. Upstream industry is the most influential node and the one that can help knowledge diffusion across adopters, regardless of their background. Self-accessible resources are major providers of information at the adoption-decision stage. The networks are centralized on self-education tools, while upstream industry and the Research Center on Animal Productions are the brokers. Policy intervention aimed at improving AKIS in the biogas sector should involve the upstream industry in decision-making, while considering the duality of self-accessible information vs. physical advisors. This paper shows evidence from a region where public incentives have allowed biogas diffusion, despite the region not being intrinsically suitable for it. Study findings may be useful for policy-makers and researchers who deal with the prevention, or mitigation, of the negative externalities of land use change via the promotion of informed technology diffusion.

1. Introduction

The lack of specific and reliable knowledge may be a stumbling block in farm-level innovation towards the bioeconomy (Kovacs, 2015). Flaws in the Agricultural Knowledge and Innovation System (AKIS), such as missing stakeholders, missing links between relevant stakeholders or ineffective knowledge transfer, may hinder farmers' ability to build their knowledge-base (EU SCAR, 2015). This is especially true for agroenergy, being the sector of the bioeconomy that relies more on inter-industry relations and knowledge networks (Golembiewski et al., 2015). Acknowledging AKIS' crucial role in the sustainable transition towards a bioeconomy, the European Commission empowers member states to effectively support and re-organize regional AKIS via their Bioeconomy Action Plans (European Commission, 2012; EU, 2013) – the Italian Bioeconomy Action Plan was released in 2016 (Italian Government, 2016). AKIS-specific measures are also included in the rural development policy 2014–2020 (e.g., public-private partnerships in agricultural research and agribusiness), which in Italy is implemented at the regional level. The EU has committed itself to AKIS' improvement and, with that aim, has invested in research (Moreddu and Poppe, 2013) to help evidence-based policy at the member-state level (Knierim et al., 2015). Here, we provide evidence about how the AKIS has allowed biogas adoption in a region[1] of Mediterranean Europe, i.e. Tuscany, Italy. Biogas is a popular and well-established biomass-to-energy technology

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[1] The twenty Italian regions are level 2 areas under the EU Nomenclature of Territorial Units for Statistics, i.e. NUTS 2.

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(Raven and Verbong, 2004), and the most widespread in Italy (GSE, 2015).

Financial incentives included in Common Agricultural Policy's direct payments and rural development programs and national feed-in-tariff schemes have reduced market risk and ensured biogas competitiveness (Lee and Zhong, 2014; Liu and Zeng, 2017), thereby encouraging plant adoption on arable farms (Scarlat et al., 2015; Bangalore et al., 2016). However, the literature has not addressed the concerns about land use shift from food/feed to energy cropping yet (Dauber et al., 2012; Kirkels et al., 2012; Lewandowski, 2015).

To date, the literature about AKIS in the biogas sector has mostly focused on northern climates (e.g., Hekkert and Negro, 2009; Markard et al., 2009). However, more varied evidence is needed from across the Union, being the EU a system of differentiated integration (Schimmelfennig et al., 2015), where the features of local agricultural systems are key for the diffusion of innovations (Capitanio et al., 2010; Hermans et al., 2015). This is especially true for Italy, where social, structural and institutional factors heavily affect innovation adoption in agriculture (Avolio et al., 2014). Knowledge retrieval from AKIS' stakeholders is critical for farmers' decision towards biogas adoption (Lundvall, 2007) and improved knowledge exchange across the system may encourage the involvement of Italian stakeholders and farmers in biogas-to-energy systems (Hodgson et al., 2016). Potential adopters would need different knowledge compared to the adopters of traditional agricultural innovation (Varis and Littunen, 2010), embedding elements from both the agricultural and energy spheres. Then, the AKIS in the Italian biogas sector is likely to differ from traditional AKIS, as, e.g., those described by Materia (2012) or Pascucci and de-Magistris (2011). Lastly, recent research has called for studies that pinpoint the peculiarities of local agroenergy systems in Italy (Magnani et al., 2017).

Some Authors offer neo-institutional perspectives on the evolution of the biogas sector and on the success of some biogas business models (Carrosio, 2013, 2014), as well as on the factors that helped or hindered the establishment of community agroenergy chains in rural areas. Other Authors describe the role of Energy Service Companies in biogas diffusion (Pantaleo et al., 2014), and assess the cost-effectiveness of public-private partnerships in agroenergy for the public sector (Fantozzi et al., 2014) to deliver guidelines for helping partnership success (Manos et al., 2014). However, at time of writing, we are not aware of published research about the AKIS in the Italian biogas sector.

Against that background, the overarching objective of this paper is to give evidence about the networks of knowledge retrieval behind policy-driven biogas adoption in a region that features arable farming systems. Specifically, this study depicts the AKIS that has delivered that knowledge and helps and understand the interplay between biogas adopters and AKIS stakeholders. Operationally, we have pursued that objective by carrying out a social network analysis of primary data collected in 2015 via questionnaire to biogas adopters in Tuscany. We turned to social network analysis, because it has proved to be a useful, but underused, tool for studying knowledge flows within the AKIS (Spielman et al., 2011). Acknowledging the suggestion of Spielman et al. (2009), this paper aims at providing recommendations to policy-makers in the act of designing support mechanisms at the micro-level, by adopting the perspective of biogas' adopters.

The paper is structured towards seven paragraphs, including this introduction. Next paragraph delivers a review of the relevant European literature about AKIS in agroenergy. After that, we present the selected case of biogas diffusion in arable farming and provide a theoretical basis for our analysis. The following paragraph is about the data collection procedure. The results and discussion paragraph depicts and comments the outputs of data processing under the selected methodological framework. In the conclusions, we pinpoint key research findings, deliver policy recommendations, and suggests improvements and directions for further research.

2. Literature review

Traditionally, the AKIS concept refers to those institutional setups where knowledge organizations operate and interact (Röling and Engel, 1991; Edquist, 2005; World Bank, 2006). To enter the age of the bioeconomy, that definition has been updated to introduce more heterogeneous, less formal and more autonomous ways of knowledge diffusion, which suggest a more complex interaction between stakeholders of the knowledge triangle (research, education, extension) and potential adopters of innovation in agriculture (Esposti, 2012). For one, the strictly agricultural perspective has opened to a system of innovation that encompasses all sectors now converging into the bioeconomy (Manos et al., 2014; Bauer et al., 2017; Hansen and Bjørkhaug, 2017). For example, diverse upstream industries (e.g. energy, chemical, pharmaceutical) take part in technology development and provide key competences and resources to enable farm competitiveness on the market (Hellsmark et al., 2016), besides firms producing seeds, fertilizers, agricultural machinery, and precision agriculture technologies. Then, those more complex systems of innovation include participation, experimentation, training, learning by doing, and AKIS-adopter interaction, while benefiting from informal institutions (Wirth et al., 2013) and e-science[2] (Esposti, 2012; Moreddu and Poppe, 2013). For example, in Italy, local environmental conditions, institutional landscape, and informal social resources underlie the local characteristics of agroenergy systems (Carrosio, 2013; Wirth, 2014; Magnani et al., 2017). E-science has received special attention by institutions, being able to improve access, exchange, and co-creation of knowledge (EU SCAR, 2015). Research findings support the political interest (e.g., Reidolf, 2016), though highlighting the need to integrate e-science with conventional (physical) AKIS (Klerkx and Proctor, 2013; Materia, 2012). Better knowledge integration may also mitigate the decreasing legitimacy of agroenergy systems (Markard et al., 2016).

The literature about AKIS in the agroenergy sector is expanding. Research has primarily considered regions of center-north Europe, where agroenergy, especially biogas, has a longer tradition compared to southern regions. Basically, there are two analytical strands, i.e. the AKIS' functions framework (Andersson and Jacobsson, 2000; Jacobsson and Bergek, 2004; Hekkert et al., 2007) and the technological innovation systems perspective (Markard and Truffer, 2008). The former involves assessing the proper (or improper) functioning of an AKIS by evaluating the functions the system should be carrying out. The functions are seven, (i) entrepreneurial activities, (ii) knowledge development, (iii) knowledge diffusion through networks, (iv) guidance of the search, (v) market formation, (vi) resource mobilization, (VII) creation of legitimacy (Hekkert et al., 2007). The latter is related to the study of technological transitions (Geels, 2002; Hoogma et al., 2002) and involves considering the reciprocal relationships across all stakeholders in the system from a micro (niche) perspective. This approach allows the researcher to highlight the factors (landscape) that influence the innovative performance of firms,

[2] E-science refers to the global infrastructure made of ubiquitous high-end computers, storage, network, and web technologies, that has increasingly supported research in many areas of science and allowed synergistic activities between different scientific disciplines (Yang et al., 2009).