Innovative Food Science and Emerging Technologies 29 (2015) 308–317

Contents lists available at ScienceDirect

Innovative Food Science and Emerging Technologies

journal homepage: www.elsevier.com/locate/ifset

The emerging research landscape on bioeconomy: What has been done so far and what is essential from a technology and innovation management perspective?

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ARTICLE INFO

Article history:
Received 8 October 2014
Received in revised form 19 December 2014
Accepted 5 March 2015
Available online 21 March 2015

Keywords:
Bioeconomy
Publication analysis
Technology and innovation management

ABSTRACT

As the global resource base is in need to move from fossil towards bio-based raw materials, different supply chains as well as existing technology platforms become increasingly interconnected. The therefore needed creation and exchange of new knowledge across scientific disciplines require R&D and target technology development and innovation, linking the knowledge-based bioeconomy to technology and innovation management research. In order to get an overview of the current research landscape dealing with the bioeconomy, a publication analysis is conducted. As the number of empirical studies, particularly in management research, is low, our study reveals that the evolution of the bioeconomy is still on a strategic level. Existing studies focus on knowledge networks, open innovation and technologies applicable across value chains to enable a holistic view on organizing future resource allocation and biomass flows. Scientific research in several dimensions is needed to elaborate the bioeconomy concept to make its implementation manageable.

Industrial relevance: Value chains, particularly of the agri-food, industrial products and energy sector, will increasingly converge due to the shift to bio-based raw materials leading to a mutual dependence and triggering new material flows and food processing technologies. This paper suggests that essential innovation management related research frames might contribute to a sustainable evolution of the bioeconomy by addressing the major challenges.

Contents

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http://dx.doi.org/10.1016/j.ifset.2015.03.006
1466-8564/

1. Introduction

The concept of a knowledge-based bioeconomy (KBBE) has been introduced by the European Commission in 2004 (Albrecht et al., 2010). However, its importance has already been highlighted before e.g., by Hardy declaring that '*The bio-based economy can and should be to the 21st century what the fossil-based economy was to the 20th century.*' (Hardy, 2002, p.11). This statement emphasizes the outstanding relevance of the bioeconomy for both academia and industry, which is also characterized by an increase of funding in recent years, particularly within Europe (Staffas, Gustavsson, & McCormick, 2013). Current European research framework programs like 'HORIZON 2020' are aiming at promoting innovations within research areas of the evolving bioeconomy (Albrecht et al., 2010; BECOTEPS, 2011; Cichocka et al., 2011; European Commission, 2012). But although the second decade of the 21st century has already begun, the concept of bioeconomy still appears to be fuzzy. The necessity of a transition from a fossil- to a bio-based economy has been emphasized; nevertheless, existing publications mainly originate from governmental institutions and are primarily concerned with strategic agendas than with the identification of challenges and measures to implement the bioeconomy. Moreover, the need for an interdisciplinary view on bioeconomy-related research seems particularly evident for research dealing with novel technologies, e.g., to enable the usage of side streams (Vaneeckhaute, Meers, Michels, Buysse, & Tack, 2013). In this context, interdisciplinary research not only faces engineering and natural sciences-related challenges but also socioeconomic challenges such as societal expectations affecting the adoption of new bioeconomic products and processes. Hence, an integration of concepts and knowledge platforms from different disciplines is required to explore the prerequisites for implementing the bio-based economy.

What could this integration look like? As the widely-used acronym KBBE already implies, the 'knowledge-based bioeconomy' demands the creation, exchange and application of (new) knowledge to support a sustainable development. These knowledge management activities require R&D and are, if successful, leading to technologies and innovations. Here, the area of technology and innovation management (TIM) research comes into play. Belonging to the research domain of management, TIM research seeks to understand how novel technologies and innovations emerge and how they can be commercialized successfully. The therewith associated research frames tackling questions such as 'from mind to market' (Afuah, 2003) seem particularly important in order to understand how to move towards the, yet, mainly technology-driven evolution of the bioeconomy. In view of the above, we conduct a meta-analysis on the emerging research landscape dealing with bioeconomy to answer the following research questions (RQ) regarding TIM-related concepts:

- RQ1: What are the current challenges depicted in the literature to move towards a bioeconomy?
- RQ2: How can the emerging research landscape on bioeconomy be characterized by means of publication analysis?
- RQ3: What has been done so far within TIM research and how can associated research frames help to address the identified challenges and manage the implementation of the bioeconomy?

The remainder of this paper is structured as follows. In Section 2, definitions and drivers of the emerging bioeconomy are discussed. In order to respond to RQ1, we particularly elaborate on the challenges concerning the implementation of the bioeconomy by employing a TIM perspective. Section 3 depicts our sampling logic as well as the findings of our in-depth publication analysis on existing research concerning the bioeconomy in order to answer RQ2. Moreover, we identify TIM-related research within the context of the bioeconomy. In the following Section 4, we compare and discuss these results with the challenges identified in Section 2 to address RQ3. This gap analysis allows us to suggest various TIM research topics which might facilitate overcoming the obstacles of the bioeconomy. The study concludes with a summary of our findings and a brief discussion of limitations in Section 5.

2. Definition and challenges of the emerging bioeconomy

Before introducing current challenges accompanying the ongoing evolution process of the bioeconomy, some definitions and data on the bioeconomy are provided.

2.1. Definition and development

The term 'biobased economy' first appeared in 2000 (Eaglesham, Brown, & Hardy, 2000). Since the mid-2000s, the literature and information base on bioeconomy is gradually growing (Staffas et al., 2013). The notion itself is composed of the words 'bio' and 'economy', which implies the concept's meaning as the '*opportunity to reconcile economic growth with environmentally responsible action*' (Bioeconomy Council, 2013, p.1) or as '*the productive (economic) uses of biomass and biomass conversions*' (Staffas et al., 2013, p.2764). The existing synonyms, i.e., bio-based economy or knowledge-based bioeconomy (KBBE), are often used interchangeably (McCormick & Kautto, 2013).

The term 'bioeconomy' has emerged in different contexts, but until now, definitions mainly derive from strategic and vision-like publications provided by public and governmental institutions, e.g., by the European Commission, the OECD and national institutions (Albrecht et al., 2010; McCormick & Kautto, 2013; OECD, 2009; Rossi & Hinrichs, 2011; Vandermeulen, Prins, Nolte, & Van Huylenbroeck, 2011). The European Commission states that '*the bioeconomy encompasses all industries and economic sectors that produce, manage, or otherwise exploit biological resources (*e.g., *agriculture, food, forestry, fisheries and the industries based upon)*' (Albrecht et al., 2010, p.13). At the national level, the Federal Ministry of Food and Agriculture in Germany emphasizes the bioeconomy as '*the knowledge-based production and use of renewable resources to provide products, processes and services in all economic sectors, within the framework of an economic system which is viable for the future*' (Federal Ministry of Food and Agriculture, 2014, p.77). These two definitions indicate the often varying perspectives and scopes applied to the bioeconomy according to the institutional and disciplinary background (McCormick & Kautto, 2013; Staffas et al., 2013; Vandermeulen, Van der Steen, Stevens, & Van Huylenbroeck, 2012; Viaggi, Mantino, Mazzocchi, Moro, & Stefani, 2012). Some authors restrict bioeconomy to biotechnology (e.g., (Biotec Canada, 2008; Birch, 2009)) or focus on bioenergy (e.g., (Coleman & Stanturf, 2006)) whereas others apply a sectoral or an even more holistic view (e.g., (European Commission, 2012; Johnson & Altman, 2014; Nita, Benini, Ciupagea, Kavalov, & Pelletier, 2013; OECD, 2009; Rossi & Hinrichs, 2011)).