Characteristics of Innovation in Bioeconomy

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Abstract

In recent years, the research field of bioeconomy has experienced significant global growth based on an increasing number of annual publications in the last 10 years. Bioeconomy received a strong political push by European policymakers after the instalment of a "knowledge-based bioeconomy" 15 years ago. While playing an essential role in recent European Union (EU) policies, bioeconomy still lacks a coherent understanding across multiple layers and especially regarding innovation activities. Innovations undoubtedly form one of the basic building blocks of the success of the knowledge-based bioeconomy and its increasing reach, but it must nevertheless be noted that frequently their innovation is not well-understood, and misconceptions prevail. Therefore, this chapter attempts to characterize innovation in bioeconomy. Based on a theoretical discussion of different concepts and aspects of innovation and a literature review at the intersection of bioeconomy and innovation, a catalogue of criteria about what can influence innovation in bioeconomy is proposed. Thus, seven criteria categories are deduced, as well as multiple keywords assigned to each of them. The proclaimed categories are then discussed and ultimately help to identify innovation triggers for bioeconomy. Thus, the article attempts to propose a realistic foundation and theoretical assessment of innovation in bioeconomy to reinforce future discourse on the matter.

Keywords

Concept of bioeconomy and innovation · Theoretical assessment · Catalogue of criteria

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1 Introduction and Motivation

In 2004, based on the knowledge-based bioeconomy, the term "bioeconomy" found its way into the policy discussion in Europe.[1] Fourteen years later, within the framework of the Global Bioeconomy Summit (GBS) in 2018, over 700 representatives from politics, science, civil society, as well as the business sector from more than 70 countries gathered up to discuss the challenges and future of bioeconomy.[2] One may expect as an outcome of such an event a polished action plan of what exactly the next steps towards the implementation of bioeconomy need to look like. The actual result, however, tends to reduce one's optimism. The question of a universal and streamlined definition of what precisely bioeconomy means includes and implicates on a global level, remained unanswered, and all that was gained is another document that offers general recommendations and states a general urgency, without providing concreteness. Especially against the backdrop of an official European Commission document—released about a year before the summit—explicitly stating the need for a common framework and giving concrete recommendations, makes the whole event appear to be redundant. Not surprisingly, more and more authors have started to focus on the negative aspects of the recent developments in bioeconomy. It has become "a buzzword used by public institutions",[3] gets criticized "for being a weak form of ecological modernization aiming for increased exploitation of natural resources"[4] and the ongoing academic discussion "about its environmental aspects and its questionable and variegated integration of sustainability perspectives"[5] gains increased publicity. Whereby at its core, bioeconomy is not just a catchword, if some things are kept in mind.[6] First of all, the attempt to frame and define bioeconomy as a sector will not lead to satisfactory results. Various authors state the need to refer to bioeconomy as a multidimensional concept instead of a sharply defined sector. One of the main reasons for that is the fact that bioeconomy in itself is exceedingly fuzzy,[7] still in its infancy[8] and is, per se, nothing new.[9] These points have had a considerable influence on the predominant definition problem of bioeconomy. In general, the bioeconomy concept entails the sustainable use of renewable biomass instead of finite fossil resources for the development and production of various bio-based, value-added products, services, and energy. These work as substitutes for existing fossil fuel-based products, services, and energy and are a part of a broader societal transition to a

[1] Cf. Golembiewski et al. (2015).
[2] Cf. von Braun (2018).
[3] Vivien et al. (2019, p. 1).
[4] Bauer (2018, p. 1).
[5] Albrecht (2019, p. 3).
[6] Cf. Golembiewski et al. (2015) and Peltomaa (2018).
[7] Cf. Golembiewski et al. (2015).
[8] Cf. Ibid. and von Braun (2018).
[9] Cf. Pietzsch (2017).

low-carbon future.[10] It also promotes the Circular Economy concept as a natural fit[11] as well as the adoption of cascading, meaning to initially process biomass into high-value products, before using the residues for lower value applications until a minimum of waste remains at the end.[12] With being primarily conceptually based, we can think of bioeconomy "as a wholesale shift in the way our economies—and necessarily our societies and polities—are organized and coordinated such that they are no longer based on fossil fuels".[13] However, in inhabiting this kind of conceptual flexibility, bioeconomy can be exploited to promote different and contrasting objectives[14] and gets gutted as an irrelevant buzzword in many publications, policies, and reports. It has proven attractive to many different actors because it can mean something for everyone—it is many things to many people.[15] Its holistic approach can thus be seen as its strength on the one hand, but also as its weakness on the other: a "fetishization of everything bio-"[16] takes places, while the role of bioeconomy as a powerful meta-discourse[17] should not be underestimated.[18] In conclusion, bioeconomy has most definitely the potential to affect a fundamental change in the industry,[19] although it is not as straightforward as many researchers, politicians, and decision-makers may think.

At the same time, our economy faces a lock-in into a fossil-based and CO_2-intensive production mode,[20] which certainly is a significant hurdle for bioeconomy to overcome. Matteo de Besi and Kes McCormick[21] see the solution in a transformative change that involves long-term approaches and interactions at all levels of society. Their vision gets supported by Birch, as he sees bioeconomy as a socio-technical transition.[22] However, "[. . .] the geographical dimensions of such transitions are often ignored or overlooked in existing research"[23] but are a vital element for a successful transition. It is indeed a transformation that would change the social, technical, and material elements of specific systems.[24] For this transition, innovation is seen by various authors as one, if not the critical factor for moving

[10] Cf. van Lancker et al. (2016) and Birch (2019).
[11] Cf. Näyhä (2019).
[12] Cf. van Lancker et al. (2016).
[13] Birch (2019, p. 2).
[14] Cf. Peltomaa (2018).
[15] Cf. Staffas et al. (2013) and Vivien et al. (2019).
[16] Birch and Tyfield (2012, 3).
[17] Cf. Bauer et al. (2018).
[18] Cf. Birch (2019).
[19] Cf. Schütte (2018).
[20] Cf. Pyka (2017).
[21] Cf. de Besi and McCormick (2015).
[22] Cf. Birch (2019).
[23] Ibid., 19.
[24] Cf. ibid.

forward.[25] However, the innovation term is again used quite inflationary, even more so in the bio-economic context. Especially in some European Union (EU) policies, the combination of both terms—bioeconomy and innovation—needs to be critically reviewed.[26] The research landscape regarding innovations in a bio-economic context appears to be quite empty so far,[27] even though the above-mentioned authors mutually agreed on it being one of the building blocks of bioeconomy. Thus, the motivation for this article is to showcase what the innovation term explicitly implicates for the concept of bioeconomy and which factors can influence innovation in a bio-economic context.

2 Innovation as a Concept

The introduction shows that bio-economic innovation is, as well as bioeconomy itself, neither well defined nor understood. Thus, this article will first focus on the theoretical foundations of innovation. The general importance and relevance of the concept of innovation were emphasized repeatedly in research both in the twentieth century and at the beginning of the twenty-first century. Especially for the (long-term) competitiveness of companies and regions, it is seen as one of the main driving forces, because of the implementation of novelty and variety. Succeeding in innovation lets companies prosper; innovative countries and regions have a higher income than less innovative ones and catching up with innovation leaders means increasing a company's innovation activity.[28] In conclusion, innovation is seen as a pretty necessary factor. However, the meaning of innovation and especially how and when it occurs are not entirely clear.[29] Innovation itself is not a new phenomenon, it is arguably as old as humankind itself.[30] While we know quite well where innovation leads to, we know much less about the why and how innovation occurs. Since multiple researchers in different working fields tried to grasp innovation and customize it to fit their specific scientific area, a certain "fuzziness" around the term and its various conceptual framings can be noticed.[31] In the following, essential currents of the different types, models, and finally, levels of innovation are briefly presented in order to form a basis for the bio-economic discourse.

[25] Cf. Golembiewski et al. (2015), van Lancker et al. (2016), Dabbert et al. (2017), Bauer et al. (2018), Purkus et al. (2018), Schütte (2018) and Birch (2019).

[26] Cf. Birch and Tyfield (2012).

[27] Cf. van Lancker et al. (2016).

[28] Cf. Fagerberg et al. (2011).

[29] Cf. Fernandes Rodrigues Alves et al. (2018).

[30] Cf. Fagerberg et al. (2011).

[31] Cf. ibid.

2.1 Innovation: Models, Types, and Levels

The linear model of innovation is, without a doubt, one of the first frameworks which got developed for understanding the relation of science and technology to economy. It implies that innovation starts with basic research, followed by applied research and development, before ending with production and diffusion.[32] However, in Jan Fagerberg's opinion, innovation has little to do with this linear model. He argues that it is based on the assumption of innovation being applied science, while in reality, firms usually innovate because of a commercial need to do so.[33] Benoît Godin opposes this by saying that the model is merely a "rhetorical entity, [. . .] a thought figure"[34] that makes the otherwise fuzzy concept of innovation easier for administrators and agencies to grasp.[35] Besides, Schumpeter is, without a question, the most influential name when talking about innovation. He invented the "trinity" of the innovation process, resulting in the indistinction between invention (new ideas are generated), innovation (ideas are developed into processes and products), and diffusion (spreading these processes and products across markets).[36] Joseph Schumpeter therefore not only introduced innovation as a process, but also made the vital distinction between invention and innovation into two separate parts of the concept, which nowadays get mixed up quite often. The linear model of innovation arose only due to interpreters of Schumpeter's work, who anchored it into the context of the technology-push and demand-pull debate.[37] Simple models, like the differentiation into product and process, as well as physical and intangible innovations, can be found as the basis of more advanced concepts (Fig. 7.1). Often used for policy recommendations, the innovation systems perspective achieved scientific attention in recent years. It combines all essential economic, social, political, organizational, and other factors that influence the development, diffusion, and use of innovations,[38] while also stressing out linkages between these actors.[39] Thus, all innovation processes are naturally embedded in innovation systems. Further, the concepts of "Technology Innovation Management" (TIM) and "Open Innovation" (OI) tend to get highlighted quite often in recent innovation literature.[40] TIM "seeks to understand how novel technologies and innovations emerge and how they can be commercialized successfully".[41] It thus attempts to decipher the most-asked question since the days of Schumpeter. OI, on the other hand, gets mentioned as a subfield to

[32] Cf. Godin (2016).

[33] Cf. Fagerberg et al. (2011).

[34] Godin (2016, p. 659).

[35] Cf. ibid. 660.

[36] Cf. Schumpeter (1939).

[37] Cf. Godin (2016).

[38] Cf. Purkus et al. (2018).

[39] Cf. Pyka (2017).

[40] Cf. Birch (2009), Golembiewski et al. (2015), van Lancker et al. (2016).

[41] Golembiewski et al. (2015, p. 2).

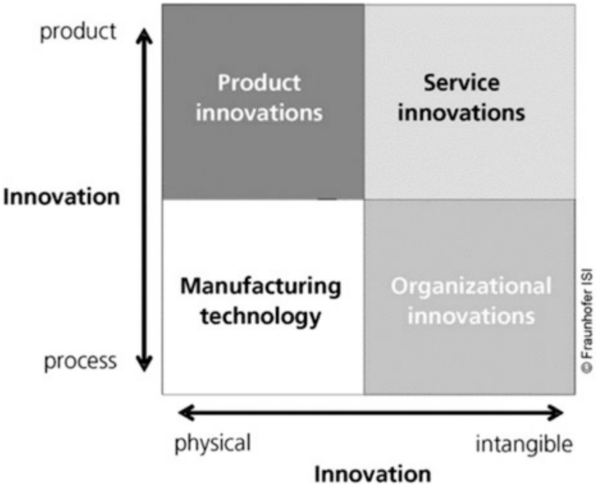

Fig. 7.1 Innovation fields in manufacturing firms (Kirner et al. 2009)

TIM that is rapidly becoming a dominant approach innovation.[42] It can be defined as "the use of purposive inflows and outflows of knowledge to accelerate internal innovation and expand the markets for external use of innovation", thus considering the "boundaries between the firm and its surrounding environment [. . .] to be more porous which allows knowledge and innovation to move more easily between the two".[43]

That leads us to one of the basic terms of the innovation vocabulary: knowledge. It provides a crucial input to innovation in that it enables actors to understand the world and make decisions that affect it.[44] Kean Birch also underlines the importance to differentiate between different types of knowledge: appropriable (restricted access) and non-appropriable (free to access),[45] as well as tacit (knowing-how) and explicit (knowing-that) knowledge.[46] These terms are essential in the further course of the article, especially for the understanding of spillovers, collaborations, and Birch's knowledge-space dynamic.

It becomes apparent that the concept of innovation can be combined with different approaches, which can be understood as a renewed indication of its adaptability but do also provide another argument for its breadth and fuzziness. Besides models, this affects types of innovation as well. Tzeng, for example, distinguishes between the following three leading schools of innovation[47] (Table 7.1):

[42] Cf. van Lancker et al. (2016).

[43] Ibid., 4.

[44] Cf. Birch (2009).

[45] Cf. Birch (2009).

[46] Cf. Nonaka and Takeuchi (1995).

[47] Cf. Tzeng (2014).

Table 7.1 The main schools of Schumpeterian innovation (Tzeng, 2014)

	Corporate capability school	Entrepreneurship school	Culture school
General perspective	Economic	Social	Cultural
Nature of innovation	Institutionalized capability	Innovation as grassroots impetuses	Innovation as deep craft
Inherent logic of innovation	Evaluate	Engage	Envision
Relationship among members	Instruction-based	Identity-based	Intergenerational

Terms like "technical innovation" and "administrative" or "management innovation" were brought forward as well, resulting in even more spin-offs, like organizational innovation.[48] The latter is defined by the Organisation for Economic Co-operation and Development (OECD) as "the implementation of a new organizational method in a firm's business practices, workplace organization or external relations".[49] It is furthermore stated that "other scholars also developed typologies for understanding organizational innovation; however, many of them are overlapped",[50] thus providing another argument for a conceptual "one size fits all"-mentality of innovation. Into the same category fall responsible innovation and social innovation. Responsible innovation includes the future-oriented organization of development and is defined as a "transparent, interactive process by which societal actors and innovators become mutually responsive to each other with a view to the (ethical) acceptability, sustainability and societal desirability of the innovation process and its marketable products".[51] Social innovation, on the other hand, emphasizes the importance of active citizenship in innovation.[52] By now, the diverse phenomenon of innovation and its redundant concept become clear.[53]

Besides the mentioned knowledge, another core term is "creative destruction", or, respectively, "incremental" versus "fundamental change". Nowadays, this dichotomy is also described as the level of innovation and, spanning back to Schumpeter, creative destruction is one of the two possibilities for change to occur. The incremental type describes small improvements along well-known trajectories, while the fundamental, or creative destruction type, which leads to structural changes, for example the emergence of new and the disappearance of old industries,[54] meaning a

[48] Cf. Fernandes Rodrigues Alves et al. (2018).

[49] Organisation for Economic Co-operation and Development/Statistical Office of the European Communities (2005, p. 177).

[50] Fernandes Rodrigues Alves et al. (2018, 3).

[51] von Schomberg (2012, 50).

[52] Cf. Pyka (2017).

[53] Cf. Kirner et al. (2009).

[54] Cf. Suroso and Azis (2015) and Pyka (2017).

"wholesale transformation of socio-technical systems".[55] By now, it has become evident that there seems to be a jungle of innovation concepts, lots of "alternative models, with their multiple feedback loops [that] look more like modern artwork or a "plate of spaghetti and meatballs" than [. . .] useful analytical framework[s]".[56] Bioeconomy by itself was identified as a fuzzy concept, and the innovation concept does not look much different. At a basic level, innovation is doing the old in a new way, while the idea behind bioeconomy is pretty much the same. Sadly, combining minus and minus does not automatically result in plus like in mathematics, so bio-economic innovations need to be individually reviewed.

2.2 Innovation in Bioeconomy

With the beginning of the twenty-first century, a paradigmatic shift towards a somewhat sustainable and smart economy is in the air.[57] Various authors agree on the appraisal of bioeconomy as one of the central factors for this change, which is unfortunately impaired by a fundamental uncertainty.[58] The creative destruction gets mentioned,[59] and the transformation process is believed to span over a large part of the twenty-first century.[60] This will lead to the reorganization of the whole world economic system, thus being an indispensable part of our future society.[61] The lack of systematic assessment, however, is seen as one of the hurdles for this transition to take place[62]; the diffuse nature and unclearness remain to be seen as problems that need fixing as soon as possible.[63] But how exactly does this *lack of systematic assessment* look like? A publication analysis, conducted in the database Web of Science Core Collection (WoS), with the advanced search string.

TS = (bioeconomy AND innovat) OR TS=(bioeconomy AND innovat*) OR TS= (bio-eco* AND innovat*),*

resulted in a total of 292 found publications in the research field of bio-economic innovations (Fig. 7.2).

The exponential growth of annual publications since 2014 can be seen, proving a significant interest in the topic in recent years. The reason behind that might be an increasing number of countries incorporating bioeconomy into their national

[55] Birch (2019, p. 18).

[56] Godin (2016, p. 660).

[57] Cf. Pyka (2017).

[58] Cf. ibid.

[59] Cf. Pyka (2017), Fernandes Rodrigues Alves et al. (2018), Schütte (2018) and Birch (2019).

[60] Cf. Saviotti (2017).

[61] Cf. Saviotti (2017) and Bauer et al. (2018).

[62] Cf. Bauer et al. (2018).

[63] Cf. Purkus et al. (2018).

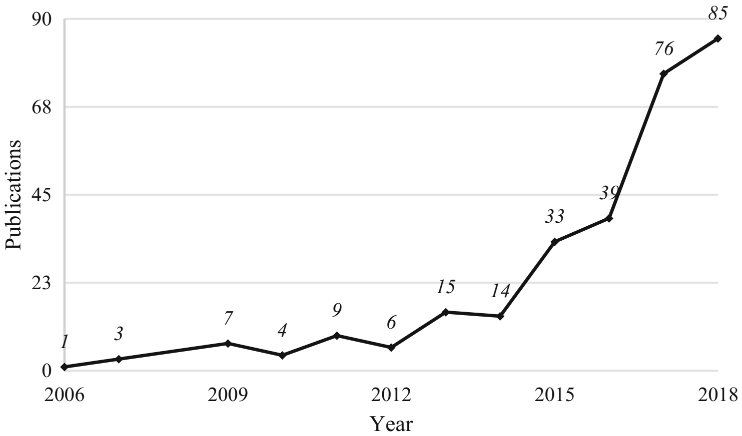

Fig. 7.2 Resulting numbers of publications in the database Web of Science

strategies and policies as well as thereby triggering scientific interest in the topic. However, of these 292 publications, only 13 include statements about bio-economic innovation factors. An explanation here could be the degree of fuzziness of both concepts. The hurdle of lacking assessment and again, the breadth of the bioeconomy concept can thus be underlined. Together with drivers that can benefit or even trigger innovations from the general innovation literature, influential factors that are found in these 13 publications can now be further looked at.

Birte Golembiewski et al. conducted a publication analysis to achieve an overview of the current research landscape dealing with bioeconomy[64] and highlight the challenges of technology and innovation management (TIM) for bioeconomy. They state the cross-sectorial character of bioeconomy and thus the need for interdisciplinary approaches. The need for broader, holistic approaches to bioeconomy can be found in other publications as well. Fredric Bauer speaks of the demand for a long-term, holistic perspective and adaptive policymaking,[65] Georg Schütte states the need for "holistic, systemic perspectives and solutions",[66] while Dries Maes and Steven van Passel reject approaches that focus on research and development alone.[67] As already briefly mentioned, knowledge is commonly seen as a core factor for innovation,[68] and this is no different in the bio-economic context.[69] Actually, in the early days of bioeconomy, it was called the "knowledge-based bioeconomy" in the European Union. Marlon Fernandes Rodrigues Alves et al. see knowledge as the

[64] Cf. Golembiewski et al. (2015).

[65] Cf. Bauer et al. (2018).

[66] Schütte (2018, p. 6).

[67] Cf. Maes and van Passel (2019).

[68] Cf. Kirner et al. (2009).

[69] Cf. Golembiewski et al. (2015).

"most important resource and thus learning as the most important process".[70] Knowledge also is deeply intertwined with location or space of origin. It can come from diverse locations and in many forms, while every spatial context is unique, knowledge entails geographical specificity.[71] Birch calls that connection the "knowledge-space dynamic".[72] He argues that innovation occurs in specific locations, where firms and other organizations have access to complementary capabilities because of their co-location and proximity to one another. Knowledge can thus leak between actors, lead to an iterative process of learning and bolster the occurrence of bio-economic innovation.[73] Birch's knowledge-space dynamic is solidly underpinned by a Schumpeterian understanding of innovation. Pyka frames it as a Neo-Schumpeterian approach: they highlight the complementary interplay in knowledge generation and diffusion processes between firms, consumers, and government institutions,[74] thus emphasizing innovation as an interactive process between multiple actors.[75] Bauer states the crucial link between university research and private sector research, therefore cross-sectoral research, while Birch also mentions the relevance of multi-scale, therefore international linkages.[76] The importance of the encompassing environment, as seen in Birch's knowledge-space model, needs to be kept in mind as well.[77] By looking at company's internal processes, factors that influence the emergence of innovation can of course also be identified there. Cheng-Hua Tzeng highlights the importance of long-time commitment to financing the development of new technologies.[78] He further argues, in the sense of the cultural innovation school, that technical innovation is not necessarily the outcome of digging information out of books or articles, but rather is a set of skills that cannot be reduced to a science.[79] Innovation in bioeconomy is seen as a "rather complex, collaborative, and multi-level process which is embedded in innovation systems",[80] and it is, in general, a good idea to "broaden one's perspective on innovation".[81] It needs to be assured, though, that there are different innovation paths. Not every firm innovates by developing new products; services can be innovative as well as the introduction of innovative manufacturing technologies or the implementation of innovative organizational concepts.[82] Jan Fagerberg et al. stated the importance of

[70] Fernandes Rodrigues Alves et al. (2018, p. 6).
[71] Cf. Birch (2009).
[72] Ibid.
[73] Cf. Birch (2009) and Birch (2012).
[74] Cf. Pyka (2017).
[75] Cf. Bauer et al. (2018).
[76] Cf. Birch (2009).
[77] Cf. Fagerberg et al. (2011).
[78] Cf. Tzeng (2014).
[79] Cf. ibid.
[80] Kirner et al. (2009, p. 1).
[81] Tzeng (2014, p. 17).
[82] Cf. Kirner et al. (2009).

the environment for innovation, which is also a major factor in the Open Innovation concept. However, Open Innovation relies heavily on trust between actors. Most collaborations are undertaken with already known partners, to reduce the risk of knowledge theft or involuntarily outgoing spillovers.[83] Of course, one could always argue that a certain openness towards new collaborations and, following that, knowledge exchange needs to be the standard case, but it is not an easy task to achieve—and definitely cannot be taken for granted. Especially with regard to the bioeconomy concept and its uncertainty, the acceptance of firms seems to be a problem and is considered a significant hindrance to innovation. Not only that, but the lack of acceptance of consumers and thus the society in general is a hurdle as well.[84] A limited consumer understanding of bioeconomy might as well reduce the market demand and the innovation capacity as a whole,[85] because apparently "a bio-economic innovation will only be successful if consumers accept it".[86] This is why authors recommend, besides Open Innovation that includes consumers and users into the innovation process, a whole portfolio of policy changes, to address all actors relevant in a given innovation system. Louise Staffas et al. argue that various national strategies and policies include innovation, but few go beyond a general recommendation.[87] The need for coherence of national and international strategies is stated widely,[88] as well as a coordinated and in-depth approach that includes entrepreneurial activities, knowledge diffusion, guidance, market formation help, resource mobilization, and the creation of legitimacy.[89] Policies especially need to account for the fact that innovation is not only taking place within R&D intensive high-tech sectors or in high-tech firms alone.[90] Bauer explains further that the transition also needs a general change of behaviour and expectations among consumers and an institutional change regarding norms, standards, and regulations.[91] He also states the need to let firms innovate at their own pace, because innovation is, as shown, nothing that can be triggered, but something that can be positively influenced. What is more, science and technology alone will not manage to solve the transition puzzle, politics need to intervene and help to initiate the change.[92] An appropriate innovation agenda, a national strategy that influences all policy areas, supports new technologies and finds new ways of financing deployment and diffusion of innovation is needed.[93]

[83] Cf. van Lancker et al. (2016).

[84] Cf. Pyka (2017).

[85] Cf. Wensing et al. (2019).

[86] Pyka (2017, p. 9).

[87] Cf. Staffas et al. (2013).

[88] Cf. Stadler and Chauvet (2018) and Schütte (2018).

[89] Cf. Purkus et al. (2018).

[90] Cf. Kirner et al. (2009).

[91] Cf. Bauer (2018).

[92] Cf. ibid.

[93] Cf. Bauer (2018) and Bauer et al. (2018).

3 Criteria for Bioeconomy Innovations

The findings of the previous chapter are now to be compiled within the framework of a criteria catalogue. Van Lancker et al. deliver a useful entry point for this. They incipiently state the importance of radically new and disruptive innovations, such as new business models, reconfigured value chains or the creation of entirely new value chains, while also considering the intricate knowledge base of various sciences. Cooperation between different actors can help develop this sophisticated knowledge, while commercialization and adoption of new bio-economic technologies and products are seen as a challenge, due to high switching costs and the locked-in state of economy. Complex and fragmented policy schemes form another challenge, as many of the new concepts are expected to comply with a number of different policy schemes and are also subject to regulation from different administrative levels. The authors conclude that "innovation processes [. . .] are best considered as transdisciplinary endeavours, open to relevant stakeholders, with ample room for iterativety between idea development, invention and commercialization".[94] Organizations need to "[strive] to innovate towards the bioeconomy"[95] while "leadership should embrace innovation and openness",[96] and the "organizational culture should reflex this".[97] "Available knowledge, expertise and technology need to be scrutinized, [. . .] relational capability and absorptive capacity need to be adequate".[98] Additionally, Tzeng emphasizes that "most important pathways include joint or cooperative ventures, contract research, consulting, informal interactions, conferences, and publications".[99] Based on the comprehensive literature work in the previous chapters, the following criteria catalogue can be established (Table 7.2).

In the following, the criteria and accompanied keywords are described in detail. Regarding *Knowledge and Awareness*, some knowledge base needs to be present. This knowledge base can consist of human capital, an experience shared inside a company, a cooperation with a research institute, or any other form that is capable of providing knowledge. The distinction between appropriable and non-appropriable knowledge is needed as well because the barriers and hurdles that need to be overcome to get inputs are important factors for the successful acquisition and should be known to the company. Besides general awareness over the recent activities in their particular working field, an idea about potential spillover effects and how knowledge flows inside, but also outside of the firm, are regarded as influential factors. Talking about the barrier between a company and the surrounding world introduces the following criteria: *openness* and *collaboration*. While the known distinction between vertical and horizontal cooperation is again more on

[94] Van Lancker et al. (2016, p. 7).

[95] Ibid.

[96] Ibid.

[97] Ibid.

[98] Ibid.

[99] Tzeng (2014, p. 6).

Table 7.2 Criteria catalogue based on literature

Number	Criteria	Keywords
1	Knowledge and awareness	Presence of knowledge base; appropriable/non-appropriable knowledge; diffusion and spillover effects
2	Openness and collaboration	Vertical/horizontal cooperation; multi-scale linkages; degree of connection; level of trust
3	Supportive environment	Proximity; supportiveness; dynamic/undynamic; suitability for innovation
4	Assisting policies and government	Coordination; holistic approach; coherency and clear understanding; funding and support; creative destruction
5	Society and consumers	Acceptance; understanding; certainty; demand for new products
6	Company management	Capability; acceptance; interactions; openness; R&D expenditures; long-term planning; demand and need
7	Feasibility	Technological, social, environmental, ecological feasibility; sufficiency and efficiency; available resources

the "beneficial-when-known-and-exploited" side of things, multi-scale linkages across more than one layer are regarded as highly potent factors for innovation. Especially when talking about the cooperation and collaborations of a company, the general rule seems to be that the more are present and used, the better, because of the unavoidable flow of knowledge. Of course, the degree and intensity of the connections and linkages are essentially important, as well as trust between the actors. Trust is an even more essential factor of the Open Innovation approach, which supports dismantling strict company boundaries about knowledge transfer and is proven to influence innovation activities. Nevertheless, not only the company itself inherits certain criteria that could potentially favour the creation of innovation, a *supportive environment* is a bolstering factor as well. Not only is proximity regarded as a big driver, because the knowledge flow can occur with a much higher frequency and also often in a face-to-face manner, but the supportiveness of the surrounding plays an essential role too. Without it, companies lose a potential partner on a political level and do also run the risk to antagonize it against them, which always creates an obstructing atmosphere. The supportiveness often influences and is directly influenced by the dynamic of a surrounding region and its actors. New ways of thinking, living, and guiding political decisions create a favourable environment that is suitable to handle innovation that may influence their daily living. *Assisting policies and government* need to have, most of all, a clear and with higher authorities coherent understanding of the target of a bioeconomy process to be able to support companies and actors at the right places and times. A holistic approach, instead of a narrow sectorial-based one to the bioeconomy can help decision-makers to receive a better outline of the term and its implications for our future but also yields a synopsis over certain connections, which otherwise would have been overseen. Funding and support can thus also reach otherwise overlooked actors and firms, and again, the aforementioned holistic view creates a bigger picture for policymakers to decide financial support on. Acknowledging the need for a transformative change and thus creative destruction of the present lock-in state can go hand in hand with open-mindedness regarding bioeconomy and innovations in general and thus is seen as another favourable factor. Not only politics and governmental activities can create a benefitting environment for innovation to occur, but also the *society and consumers* play a significant role. The importance of their acceptance and understanding of bio-economic principles has already been described, but a particular degree of certainty regarding future developments in economy but also politics supports them in making educated decisions and take on a progressive standpoint. At the consumer side, the demand for a new product or process can create an increasingly strong pull and thus urges actors to come after it, often being innovative in adapting their production systems to the new market demand. *Company management* naturally needs financial and social capability in order to be actively engaged in innovative activities. Acceptance and also knowledge about said bio-economic principles is regarded as important as allocating R&D expenditures. The significance of a certain openness, especially towards incoming and not-yet-known linkages and further towards broader ideas, developments, and implications, was again described above. Long-term planning does not favour innovative undertakings on its own, but when paired with knowledge about the need to change current economic or ecologic behaviour can become a driver for innovation. Watching the market demand closely and acting upon being aware of potential gaps may also provide companies with opportunities to establish new products. The last criterion that got deducted is *feasibility*. It can be seen as an outlier because it is assumed that innovation is not triggered simply because something is feasible or not. Rather it should be seen as a supportive criterion once an innovation is already on its way to establishment. It was shown that innovation needs implementation; if any one of the technological, social, environmental, or ecological feasibility is not given, implementation will face serious barriers along its way. The same holds for sufficiency and efficiency; innovators need to assure both for a smooth transition from the invention- to the innovation-phase. Lastly, the needed resources need to be available and adequate with a sustainable infrastructure in place.

At this point, the question about criteria specific to bioeconomy rises; the literature review did not yield any specifics, which is why the above criteria catalogue does not include any. One may think initially of sustainability as a criterion. However, sustainability is another buzzword, encompassing already existing criteria and thus would only add another unnecessary layer on top of the other two, bioeconomy and innovation. A company may undertake activities that result in innovation, but the actual reasoning behind it is often not the need or want to be more sustainable, but to be more efficient or effective, and thus it may use sustainability as a disguise. Otherwise, when a company is forced by an external entity to be more sustainable, sustainability can be seen as a trigger for innovation. Actors that use biological resources, biomass, see themselves as sustainable by definition, as their work needs to be in a sustainable manner in order to secure their livelihood for the present and future. Sustainability is promoted on many political levels, present in the policy discussion for at least 20 years, and promoted all over the world, whereas at its core, it is the simple concept of not destroying what you live on. *Sustainability* may thus be regarded as a trigger for bio-economic innovations but will not be included in the above catalogue, because of its overusedness, buzzword-character, and unspecific approach.

4 Conclusion

Innovation plays a vital role in our modern economy and society. Bioeconomy, especially in light of the ongoing development of a "new green revolution", appears to manifest itself as an essential factor when talking about possible ways out of a fossil lock-in. With the help of a literature review and a theoretic outlook, this article highlights what factors possibly influence innovation in the context of bioeconomy. Its relevance thus lies in providing a holistic overview of the combination of two terms that are by themselves not easy to frame, thus making the first step towards a remarkable, new research area within the growing bioeconomy discourse. The importance of a shift towards this new economic principle has been stated numerous times in recent years. As this catalogue of criteria is based solely on theory, it needs to be validated with practical examples as a next step; the work on it is far from finished. However, using it as a mere guideline should provide researchers with a good foundation for their work. The article's general approach towards innovation and bioeconomy topics may also help conceiving them from another, maybe new, point of view. However, what has also become clear is the lack of criteria unique to bioeconomy in the literature. Neither the cascading nor the circular economy approach are mentioned as triggers for innovation, while they are perfect examples for innovation out of necessity and thus need to be further investigated. Then again, because bioeconomy cannot be described as a single economic sector, but rather as a concept that spans across multiple sectors, finding particular innovation criteria for it is not an easy task. Sustainability was mentioned but got disregarded because of its comprehensive approach. This means that, in the end, innovation in bioeconomy seems to be based mostly on general criteria. Thus, as a result, the conceptuality of the innovation term can be underlined as well as the broadness of bioeconomy itself which leads to the insight that further research on the topic is still needed.

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