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Article — Published Version

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Business Strategy and the Environment

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John Wiley & Sons

Suggested Citation: Hinderer, Sebastian; Kuckertz, Andreas (2022) : The bioeconomy transformation as an external enabler of sustainable entrepreneurship, Business Strategy and the Environment, ISSN 1099-0836, Wiley, Hoboken, NJ, Vol. 31, Iss. 7, pp. 2947-2963, <https://doi.org/10.1002/bse.3056>

This Version is available at:

<https://hdl.handle.net/10419/266672>

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RESEARCH ARTICLE

The bioeconomy transformation as an external enabler of sustainable entrepreneurship

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Funding information

European Union

Abstract

Bioeconomy strategies worldwide emphasize the importance of entrepreneurship in the transformation toward a sustainable and circular bioeconomy. However, the bioeconomy transformation itself also offers great opportunities for creating new ventures. Based on interviews with bioeconomy entrepreneurs from six European countries, we investigate how entrepreneurial opportunities emerge in the bioeconomy context and what competencies entrepreneurs need to act on them. By conceptualizing the bioeconomy transformation as an external enabler of entrepreneurial activity, we open new avenues for research on sustainable development and innovation policy. We conceptualize sustainable entrepreneurship as a phenomenon that can be enabled externally via the transformation toward sustainable development. Furthermore, we show that new venture creation in the bioeconomy requires unique knowledge (*transformative knowledge*) and specific competencies (*sustainable valorization of biomass, marketing of biobased products, and management of limited resources*).

KEYWORDS

bioeconomy, competencies, external enablement, sustainable development, sustainable entrepreneurship, sustainable innovation policy

1 | INTRODUCTION

Early conceptualizations of sustainable entrepreneurship (SE) described sustainable entrepreneurs as individuals who respond to environmental degradation or social harm by identifying and exploiting relevant entrepreneurial opportunities and creating ventures (Cohen & Winn, 2007; Dean & McMullen, 2007). Therefore, SE is “focused on the preservation of nature, life support, and community in the pursuit of perceived opportunities to bring into existence future products, processes, and services for gain, where gain is broadly construed to include economic and non-economic gains to individuals, the economy, and society” (Shepherd & Patzelt, 2011).

In entrepreneurship research, and in line with the seminal paper by Shane and Venkataraman (2000), the SE field describes the

entrepreneurial process as consisting of opportunity recognition, evaluation, and exploitation. Consequently, the idea of the individual–opportunity nexus (Shane & Venkataraman, 2000), which describes the fit between an entrepreneurial opportunity and the individual pursuing it (Davidsson, 2015), is a key concept. Shane and Venkataraman (2000) argued that questions of “why, when and how” entrepreneurial opportunities emerge and “why, when and how” entrepreneurs act on them are central in entrepreneurship research. Moreover, contextualization is a critical factor in understanding entrepreneurship, especially “why, when and how” entrepreneurship happens and who becomes involved in the entrepreneurial process (Welter, 2011).

However, for SE in general and for SE in the bioeconomy transformation context, it remains unclear how entrepreneurial

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opportunities emerge and how entrepreneurs act on them. Although scholars have proposed different interpretations and visions of the bioeconomy (Bugge et al., 2016; Vivien et al., 2019), it is widely understood to encompass “all primary production sectors that use and produce biological resources (agriculture, forestry, fisheries and aquaculture); and all economic and industrial sectors that use biological resources and processes to produce food, feed, bio-based products, energy and services (...) [with] sustainability and circularity at its heart” (European Commission, 2018, p. 4).

Scholars have made initial attempts to describe the bioeconomy's specific opportunity space (Kuckertz et al., 2019) and the relevant business models (D'Amato et al., 2020) and business strategies (Fotiadis & Polemis, 2018; Urbaniec et al., 2022). However, conceptualizations of entrepreneurship in the bioeconomy have remained rather simplistic, and little is known about the processes of opportunity identification, evaluation, and exploitation (Kuckertz et al., 2020).

The bioeconomy transformation provides valuable opportunities for sustainable development in alignment with the United Nations Sustainable Development Goals (Ronzon & Sanjuán, 2020) and thus for SE (Esteves et al., 2021; Kuckertz, 2020; Sehnem et al., 2021; Viaggi, 2015). Consequently, several countries have developed dedicated bioeconomy strategies (German Bioeconomy Council, 2018), highlighting SE's critical role in a successful bioeconomy transformation (Kuckertz, 2020).

Previous research addressed the question of how sustainable entrepreneurs act on entrepreneurial opportunities and acknowledged that SE requires specific knowledge and competencies (Muñoz & Cohen, 2018; Patzelt & Shepherd, 2011). Various scholars have addressed this question by considering entrepreneurship training programs in higher education (Biberhofer et al., 2019; Focurier & Wiek, 2019; Lans et al., 2014; Ploum et al., 2018; Renfors, 2020). Such studies typically present SE competence frameworks in general terms, without specifically examining the bioeconomy context. However, entrepreneurship education requires discipline-based frameworks that account for profession- or industry-specific entrepreneurial competencies (Thomassen et al., 2020).

Therefore, we posed the following two research questions:

1. How do entrepreneurial opportunities emerge in the bioeconomy context?
2. What skills and competencies do sustainable entrepreneurs need to act on such opportunities?

We approached the bioeconomy transition as an external enabler, building on Davidsson et al.'s (2020) framework for new venture creation through external enablement (EE) and Davidsson's (2015) reconceptualization of the individual–opportunity nexus. This reconceptualization distinguishes between objectively existing external enablers that may potentially trigger entrepreneurial activity and subjective assessments by potential entrepreneurs who may eventually act on these enablers (Davidsson, 2015). External enablers include “external conditions such as new technologies; regulatory or demographic shifts; and changes to the socio-cultural, economic, political,

or natural environments” (Davidsson et al., 2020, p. 311). Consequently, the EE framework allows treating the bioeconomy transition as a set of changing external conditions that trigger entrepreneurial activity.

Based on this framework, we propose a model of the individual–opportunity nexus for the bioeconomy that describes how entrepreneurial opportunities emerge and what knowledge and competencies sustainable entrepreneurs need to act on such opportunities. Consequently, this article makes three contributions to the existing literature. First, by analyzing the bioeconomy context, we extend the frameworks that describe the skills and competencies needed for SE and show that such skills and competencies are sector-specific. Second, by applying the EE framework, we substantiate our understanding of SE in the bioeconomy context and show that there is a mutually beneficial relationship between SE and the transformation toward sustainable development. Third, by introducing the EE framework, we open new avenues for future research on transformation and innovation policy.

The rest of this article is structured as follows: First, we examine the relevant literature. Second, we explain our research design. Third, we present our results, including the model of the individual–opportunity nexus in the bioeconomy. Finally, we discuss our findings and their implications for theory and practice.

2 | THEORETICAL FRAMEWORK

In the entrepreneurship field (Shane & Venkataraman, 2000), entrepreneurial opportunities and their identification, evaluation, and exploitation are considered central to SE (Belz & Binder, 2017; Eller et al., 2020). We contribute to this field by looking at (1) how sustainable entrepreneurial opportunities emerge in the context of the bioeconomy transformation and (2) what knowledge and competencies are needed to act on such opportunities. Therefore, we build on Davidsson's (2015) recent reconceptualization of the individual–opportunity nexus and the EE framework for entrepreneurial activity. In the rest of this section, we first discuss the EE concept and apply it to SE in the bioeconomy. Second, we review the extant literature on SE competence frameworks and point out their shortcomings in relation to SE and the bioeconomy.

2.1 | External enablement of new venture creation in the bioeconomy

Davidsson's (2015) reconceptualization of the individual–opportunity nexus provides an alternative perspective on the relationship between individuals and opportunities by introducing the concepts of *external enablers* (e.g., regulatory changes, technological breakthroughs), *new venture ideas* (i.e., “imagined future ventures”), and *opportunity confidence* (i.e., an individual's subjective favorability assessment of an *external enabler* and/or a *new venture idea*). What distinguishes the framework from previous research on entrepreneurial opportunities is

its proposed division between a particular venture's aims (new venture idea) and the perceived beneficial external factors (external enablers) (Davidsson et al., 2020).

Moreover, the framework allows theorizing how external enablers, such as technological breakthroughs, regulatory changes, or socio-cultural and natural-environmental developments, trigger and facilitate entrepreneurial activity (Davidsson et al., 2020). Therefore, the framework is perfectly suited for explaining entrepreneurial activity in the context of the bioeconomy transition. The transition toward a sustainable bioeconomy involves a complex interplay of many factors (Hinderer et al., 2021), with innovation fostered by entrepreneurial activity being a central element (Kuckertz, 2020). However, we argue that the transition itself also serves as an external enabler of entrepreneurial activity. In other words, entrepreneurial activity and the transition toward a sustainable bioeconomy share a two-way mutually beneficial relationship.

The EE framework conceptualizes external enablers according to three elements (Davidsson et al., 2020). First, *characteristics* describe an external enabler based on its scope and onset, determining its actionability and market potential. Second, *mechanisms* describe an external enabler's function by specifying the cause-effect relationships that external enablers generate. Third, *roles* describe an external enabler's higher-order functions (e.g., triggering, shaping, outcome-enhancing) at different stages of the new venture's development process. Below, we outline the relevant aspects of the bioeconomy transition understood as an external enabler of entrepreneurial activity.

2.1.1 | Characteristics

The characteristics of an external enabler include its spatial, temporal, sectoral, and socio-demographic scope as well as its onset defined according to gradualness, predictability, and evolution (Davidsson et al., 2020; Kimjeon & Davidsson, 2021). The spatial scope of the bioeconomy transition is multi-faceted. Although dedicated bioeconomy strategies are being developed worldwide (German Bioeconomy Council, 2018), such strategies can have a multi-national, a national, and sometimes even a regional focus (de Besi & McCormick, 2015). The strategic regional focus is not surprising as, in developing and developed countries, the bioeconomy transition is related to regional development hopes (Callo-Concha et al., 2020; Refsgaard et al., 2021). Specifically regarding sustainability, the bioeconomy's regional scale is essential because it allows entrepreneurs to adapt to locally available biomass and reduces transportation costs as well as greenhouse gas emissions (Pfau et al., 2014).

As the updated bioeconomy strategy of the European Union (EU) shows, bioeconomy in Europe is multi-sectoral but can be mainly divided into two sectors: the sectors that mainly supply biomass, such as agriculture, forestry, fishing, and aquaculture, and the sectors that use biomass, such as food and beverages, bioenergy, or biobased chemicals and materials (European Commission, 2018). Moreover, the processing and valorization of biomass has benefitted significantly from advances in industrial biotechnology (Dupont-Inglis & Borg, 2018).

The EU's bioeconomy strategy says a lot about the onset of the bioeconomy transition as an external enabler. While the strategy's first version was launched in 2012 (European Commission, 2012), the updated version was released in 2018 (European Commission, 2018). On the one hand, this shows the relatively gradual development of the discourse about the bioeconomy transition and, on the other hand, its relatively high degree of predictability.

2.1.2 | Mechanisms

Although characteristics describe an external enabler's nature, the mechanisms category provides more details on an external enabler's influence on entrepreneurial activity (Davidsson et al., 2020). First, opacity describes "the extent to which the benefits of an enabling mechanism for specific purposes is rather obvious or requires specialized knowledge and/or extraordinary imagination" (Kimjeon & Davidsson, 2021, p. 5). Second, agency intensity describes "the extent to which activation of an enabling mechanism requires tenacity, risk-bearing and resource investments" (Kimjeon & Davidsson, 2021, p. 5).

Although Kimjeon and Davidsson (2021) proposed several potentially beneficial mechanisms for entrepreneurial activity, the following two mechanisms are best suited for describing the bioeconomy transformation case: *resource creation*—"making a previously nonexistent (type of) resource available to the focal venture" (Kimjeon & Davidsson, 2021, p. 4)—and *resource substitution*—"replacement of one resource with another for the focal venture" (Kimjeon & Davidsson, 2021, p. 4). Overall, the bioeconomy transition aims, by definition, to enhance the utility of renewable biogenic resources in phasing out finite fossil resources.

In the bioeconomy transition context, the concept of cascading biomass use (see Figure 1) plays an important role (Laibach et al., 2019). Cascading biomass use describes the efficient use of biomass for different purposes over time (e.g., residues from agricultural food production being used to produce bioplastics, and residues from bioplastic production being used for energy generation; Keegan et al., 2013; Zörb et al., 2018). In addition, cascading biomass use closes material and energy flows by transforming linear production processes into circular ones (e.g., by using digestate from biogas production as fertilizer for new biomass cultivation; Keegan et al., 2013; Zörb et al., 2018). Consequently, we closely link the bioeconomy transition's enabling mechanisms with the concept of cascading biomass use.

In addition to the supply perspective (i.e., the cascading use of biomass), the demand perspective of the bioeconomy transition entail further enabling mechanisms. In the bioeconomy transition, consumers are active actors (Wilke et al., 2021) and generally tend to buy biobased products (Wensing et al., 2021). Therefore, the bioeconomy transition also provides beneficial enabling mechanisms through *demand creation*—"the creation of demand for a product/service where no demand previously existed" (Kimjeon & Davidsson, 2021, p. 4)—and *demand substitution*—"increase in demand that is due to making a focal venture's market offerings more needed/attractive or competitors' offerings less needed/attractive" (Kimjeon & Davidsson, 2021, p. 4).

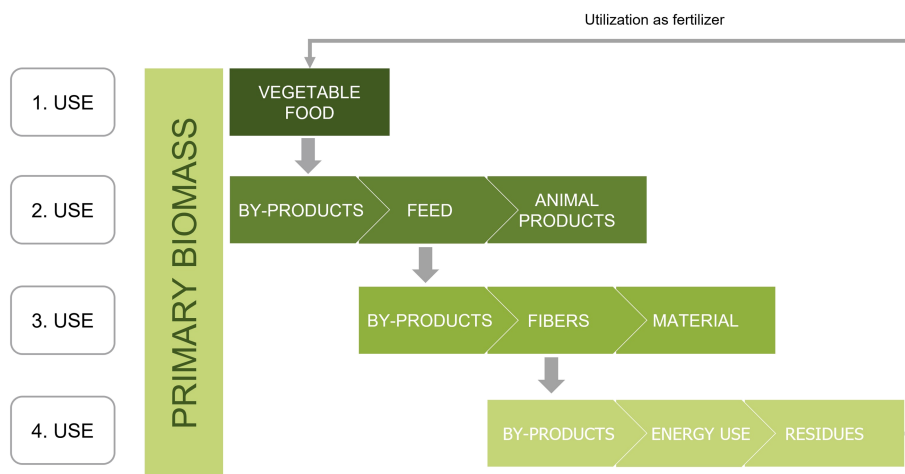


FIGURE 1 Concept of cascading biomass use based on Zörb et al. (2018)

As a consequence of changed consumer demand due to higher sustainability awareness, a further enabling mechanism becomes relevant for the bioeconomy context: legitimation, the “increase in the legality or psychological/socio-cultural acceptability of the focal venture, its offerings, or its practice, or reduction in such acceptability of competitors” (Kimjeon & Davidsson, 2021, p. 4). Considering public discourse on sustainability and climate change, it seems reasonable that the socio-cultural acceptability of sustainable bioeconomy ventures should increase, while that of competitors who completely neglect the principles of sustainable development should decrease.

2.1.3 | Roles

In the EE framework, roles refer to the higher-order functions that external enablers play during the venture creation process (Davidsson et al., 2020). The EE mechanisms brought about by the bioeconomy transition mainly play triggering and shaping roles. Previous research has shown that the bioeconomy transition triggers entrepreneurial activity in various sectors (Kuckertz et al., 2019; Urban et al., 2017). However, the cascading use of biomass, as described above, is not only the reason behind resource- and demand-related mechanisms; but also determine the *product shaping*—“EE influencing the focal venture's product(s) or service(s)” (Kimjeon & Davidsson, 2021, p. 5)—and *market shaping*—“EE influencing the focal venture's choice of spatial, sectoral, or socio-demographic market(s)” (Kimjeon & Davidsson, 2021, p. 5)—role of the bioeconomy transition as an external enabler.

2.2 | SE competence frameworks

Scholars have proposed different SE competence frameworks, all mainly intended to contribute to SE training programs in higher education. However, no specific framework has been developed for the context of the bioeconomy transformation. Lans et al. (2014) laid the foundation for SE competence frameworks by linking sustainable

development competencies with entrepreneurship competencies. The resulting integrated framework was later validated in a separate study (Ploum et al., 2018) and included six competencies: system thinking competence, embracing diversity and interdisciplinary competence, foresighted thinking competence, normative competence, interpersonal competence, strategic management, and action competence.

Other competence frameworks (Biberhofer et al., 2019; Renfors, 2020) have built on this framework. Renfors (2020) explicitly focused on business competencies, while Biberhofer et al. (2019) extended the framework's scope beyond competencies toward values and worldviews. The resulting frameworks reflect different perspectives. Biberhofer et al.'s (2019) framework is highly similar to Ploum et al.'s (2018) validated framework and includes the following five competencies: systemic competence, anticipatory competence, normative competence, strategic competence, and interpersonal competence. By contrast, Renfors's (2020) competences reflect the business perspective: product development competence, consumer communication competence, brand management competence, supply chain competence, digital competence, and strategic management competence.

Interestingly, these frameworks all emphasize the concept of entrepreneurial opportunities (Biberhofer et al., 2019; Lans et al., 2014; Renfors, 2020) by stating that the identification and pursuit of business opportunities (i.e., the individual–opportunity nexus) are distinctive features of entrepreneurship (Biberhofer et al., 2019; Lans et al., 2014). However, none of these studies have explicitly included the individual–opportunity nexus or the entrepreneurial process of opportunity recognition, evaluation, and exploitation in their frameworks.

Against this background, Foucrier and Wiek (2019) proposed a process-oriented SE competence framework. As the framework was based on an extensive review of research on entrepreneurship, sustainability, social entrepreneurship, and SE, the identified competencies overlap with those of the frameworks described above. This framework's novelty lies in its process-orientation, which links SE competencies and SE tasks using five process steps ranging from “discovery” to “consolidation” (Foucrier & Wiek, 2019). However, the framework's broad scope results in the individual–opportunity nexus receiving little attention.

By applying the EE concept, we develop a framework that explains how entrepreneurial opportunities emerge in the context of the bioeconomy transformation and what competencies are needed to act on such opportunities. In the next section, we outline our research design and methods in detail.

3 | METHODS

We employed a qualitative research design to explore the new venture development process of young bioeconomy startups. More specifically, we conducted semi-structured interviews with bioeconomy entrepreneurs. The analysis of the gathered data was twofold. First, we used the Gioia approach (Gioia et al., 2013) to create a data structure and identify the concepts inherent in the data. Second, we engaged with the existing literature in the bioeconomy and (sustainable) entrepreneurship fields to complement our development of an SE model for the bioeconomy context (Shepherd & Sutcliffe, 2011).

3.1 | Data collection

To identify and select interview partners, we relied on the networks of the partner institutions associated with the European Bioeconomy University, a joint undertaking of six European universities for educating bioeconomy experts, fostering research, and transferring knowledge to society and the economy (European Bioeconomy University, 2019). In line with the European Commission's bioeconomy definition (European Commission, 2018) and the EE framework (Davidsson et al., 2020), we defined bioeconomy startups as follows:

Bioeconomy startups are the result of new venture creation that is externally enabled by the bioeconomy transformation. They seize the opportunities for entrepreneurial activity provided by the bioeconomy transformation by producing biological resources, offering products and services related to the production of such resources, and/or by using biological resources and processes to offer products or services related to food, feed, biobased products, and energy, all the while considering sustainability and circularity.

In total, we selected 10 (co-)founders of bioeconomy startups from six different European countries that matched our definition, were younger than seven years, and pursued an innovative business model (Table 1). We screened firm websites and news articles for potential interviewees and checked the suitability and compliance of the startups with the inclusion criteria. The screening process also served as interview preparation and provided us with background information and context. Furthermore, we selected interviewees from each level of the biomass cascade.

3.2 | Interviews

We conducted and recorded semi-structured interviews via the video conferencing software Zoom. In total, we recorded 9 h 35 min of video interviews, with an average duration of 53 min per interview. We asked the interviewees about (1) their personal backgrounds and (2) their ventures' business models to gain a better understanding of the context before asking them about (3) their process of starting up and (4) the challenges they were confronted with (the complete interview guidelines can be found in Appendix A). While the first two questions provided us with information about the context in which the startups were operating, the answers to the other two questions revealed the process of opportunity identification, evaluation, and exploitation. We avoided explicitly asking about the opportunity identification process or knowledge and competencies to keep the questions as open as possible. We engaged the services of a professional transcription company (AmberScript) to transcribe the collected recordings, resulting in 152 single-spaced pages of text.

3.3 | Data analysis

We used the MAXQDA software to process the data by applying the following steps (Gioia et al., 2013): First, we employed open coding to identify first-order concepts regarding what knowledge and competencies entrepreneurs need to identify and act on opportunities in the sustainable circular bioeconomy context. Second, we used axial coding to generate second-order themes. Third, based on second-order themes, we established the aggregate dimensions of a framework for describing what knowledge and competencies are required to act on SE opportunities in the bioeconomy context. To ground our findings in the data, we allowed codes to emerge without having a predefined list (Bryant & Charmaz, 2007). The open-coding process resulted in a large number of first-order concepts, which we then distilled into more abstract second-order themes using an iterative process of axial coding and later into aggregate dimensions, thus building the data structure (Gioia et al., 2013). Whenever possible, we used in vivo coding in open coding to give the interviewees a voice (Bryant & Charmaz, 2007; Gioia et al., 2013; Saldaña, 2013). Once the first interviews had been coded, our evolving understanding of the coding scheme resulted in adjustments to our interview guidelines for the remaining interviews (Strauss & Corbin, 2003). Finally, we terminated data collection once we had achieved theoretical saturation (Glaser & Strauss, 1967).

Only then did we begin to engage deeply with the extant literature (Corley & Schinoff, 2017) to complement our development of a model for new venture creation in the bioeconomy context. Engaging with the extant literature helped us to understand how our findings from the inductive analysis of the interview data could explain new venture creation in the bioeconomy context. We used the emerging concepts from the data structure to incorporate the existing frameworks of cascading biomass use and EE into our model of new venture creation in the bioeconomy. Overall, our model reveals useful

TABLE 1 Interviewees

No.	Sector	Level of biomass cascade	Country	Founding date	Business model	Interview duration
1 ^a	Forestry	Primary production	Finland	2015	Measurement technology for timber	00:53:50
	Bioenergy	Energy recovery			Plant technology for torrefied pellets	
2	Wood processing (furniture)	Material usage	Poland	2020	Processing technology for bended wood products	01:01:52
3	Food	Food production	Germany	2017	Snacks from unused food-industry byproducts	00:51:59
4	Agriculture (smart farming)	Primary production	Germany	2018	Drone-based herbicide application maps	00:56:18
5	Food, cosmetics (ingredients)	Food production, material usage	Austria	2019	Processing of fruit pits into raw material for new products	00:39:42
6	Marine cultivation	Primary production	Netherlands	2019	Living breakwater technology for cultivating marine ecosystems and protecting shore lines	00:54:05
7	Fashion	Material usage	Netherlands	2018	Vegan high-quality fabrics from mycelium	00:50:54
8	Food, cosmetics (ingredients)	Food production, material usage	France	2019	Re- and up-cycling of eggshells	00:53:56
9	Bioenergy	Energy recovery	Germany	2019	Ball mill to shred biomass for biogas plants	00:47:42
10	Food	Food production	Austria	2019	Natural chewing gum from pine resin	00:58:56

^aInterviewee 1 co-founded two different bioeconomy startups that were both discussed in the interview.

insights for both the bioeconomy and SE fields, something that has been rarely done before.

4 | RESULTS

Figure 2 shows the data structure that emerged from the coding process. The representative quotations in Appendices B–E exemplify how the data structure emerged from the interview transcripts. The data structure contained 14 second-order themes, which can be further summarized into four aggregate dimensions describing the knowledge and competencies needed to seize the entrepreneurial opportunities provided by the bioeconomy transformation. These aggregate dimensions served as the building blocks for our conceptualization of sustainable venture creation enabled by the biomass cascade and the bioeconomy transition and thus for the model in Figure 3. Building on Davidsson (2015, p. 689), we found that new sustainable venture creation depends on the actor–external-enabler nexus, which, in the bioeconomy context, is represented by the sustainable entrepreneur (actor) and the bioeconomy transition (external enabler).

The conceptualization of the actor–external-enabler nexus allowed us to distinguish between objectively existing enabling factors and sustainable entrepreneurs' subjective perceptions of and actions on such factors when creating new sustainable ventures (Davidsson, 2015). Our research revealed that at the individual level, sustainable entrepreneurs need specific competencies and knowledge

to take advantage of the enabling function performed by cascading biomass use. On its own, the enabling function of cascading biomass use is not a sufficient condition for creating a new sustainable venture in the bioeconomy context. Instead, the agency exerted by a subject—that is, a sustainable entrepreneur—is also needed.

More specifically, sustainable entrepreneurs need *transformative knowledge*—that is, knowledge of transforming systems (Urmetzer et al., 2018). Transformative knowledge enables sustainable entrepreneurs to assess whether a new venture idea has the potential to generate profit and contribute to the targeted transformation toward a sustainable and circular bioeconomy, the fundamental rationale behind SE (Stubbs, 2017). Transformative knowledge generally requires (1) systems knowledge about how relevant systems work and (2) normative knowledge about the desired system states (Urmetzer et al., 2018). For new venture creation in the bioeconomy context, this means (1) understanding the regionality of biomass value chains and incorporating it into the business model and (2) being able to assess the business model's favorability and desirability in terms of its social-ecological sustainability.

This does not mean that new sustainable ventures can only operate at the regional level. However, the regional nature of biomass value chains influences the overall sustainability impact of products and services created from such biomass value chains. And sustainable entrepreneurs need to consider this factor, especially when expanding their businesses. Therefore, sustainable entrepreneurs need to be able to measure their sustainability impact and understand the main factors behind it; only then can they align with the overall goal of a

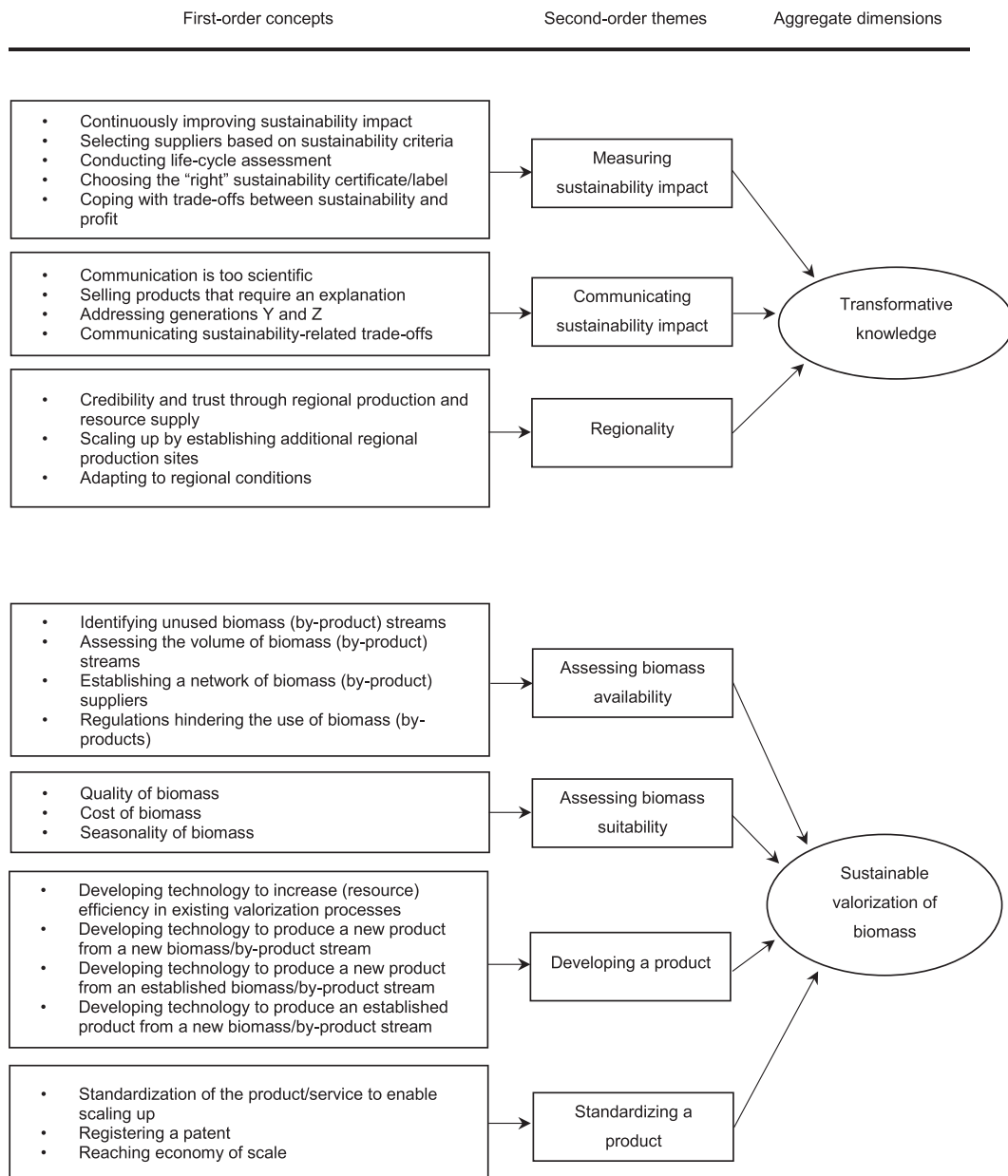


FIGURE 2 Data structure

transformation toward a sustainable and circular bioeconomy. In addition, sustainable entrepreneurs need to successfully communicate their sustainability impact to relevant actors, such as customers, investors, or community members, as this is necessary for unleashing the full transformative potential of their ventures.

To unlock the positive potential of cascading biomass use, sustainable entrepreneurs should pay attention to the following three aggregate dimensions of the data structure: *sustainable valorization of biomass*, *marketing of biobased products*, and *management of limited resources*. While transformative knowledge enables sustainable entrepreneurs to assess the desirability of new venture ideas, sustainable valorization of biomass enables sustainable entrepreneurs to evaluate the feasibility of their

ideas—that is, to assess the quantity and quality of biomass and to develop a product that solves real customer problems.

Technology plays a key role in the development of biobased products. It enables various ways of exploiting established or new biomass sources to produce new products or replace established fossil-based products (Bröring et al., 2020). Furthermore, technology can improve resource efficiency in established biomass valorization processes. Due to the significance of technology in new bioeconomy ventures, registering patents is key for many ventures to protect their intellectual property when going to market. Moreover, bioeconomy entrepreneurs need to standardize their products and services to scale up their business and benefit from economies of scale.

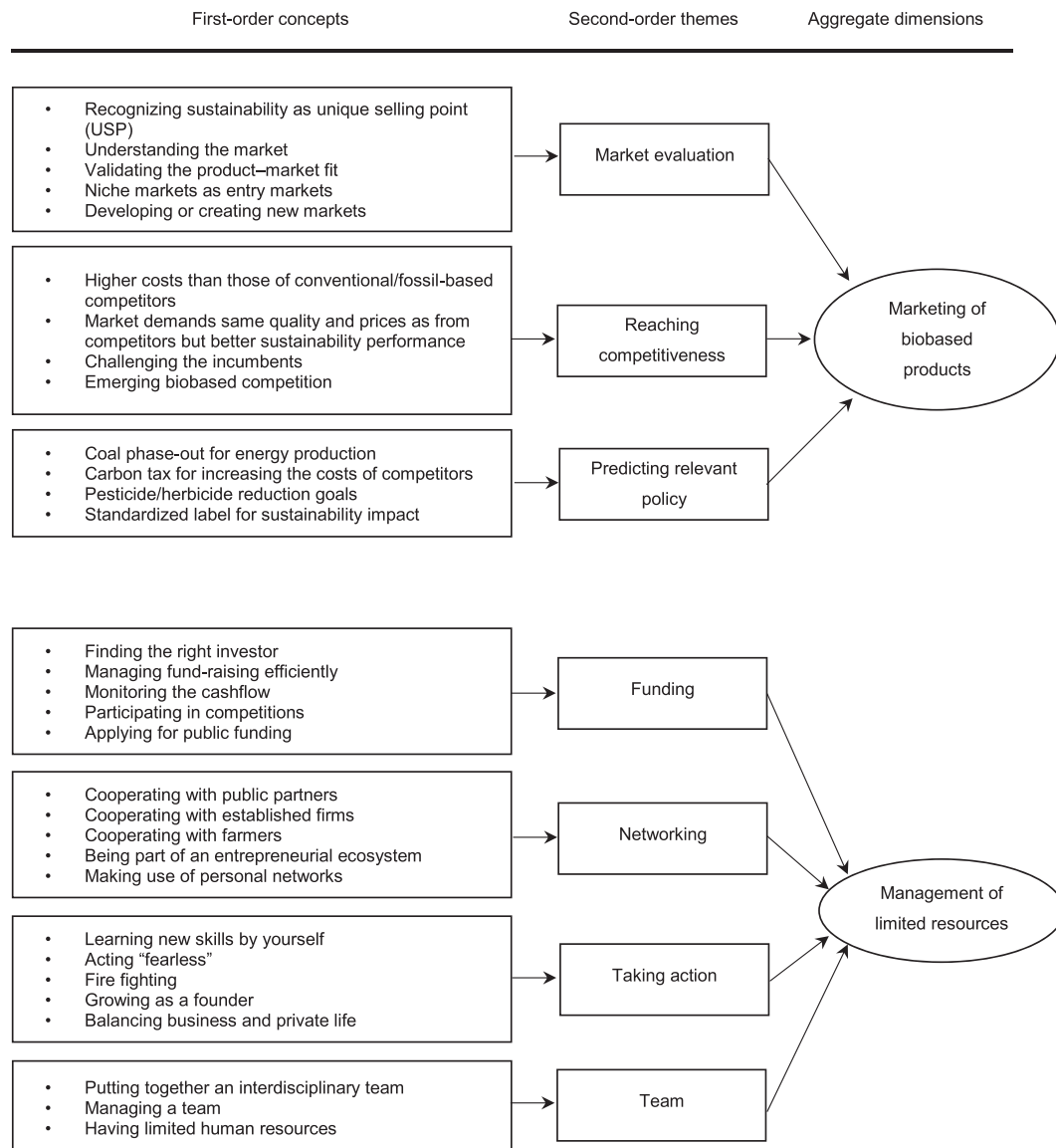


FIGURE 2 (Continued)

To assess the demand for their products and services, sustainable entrepreneurs need to engage in the marketing of biobased products. To do this, they must evaluate the market for biobased products. Frequently, sustainable entrepreneurs offer biobased and more sustainable alternatives to incumbents' products, which are based on nonrenewable resources but are highly competitive in terms of price and market penetration. Therefore, sustainable entrepreneurs need to evaluate the market and search for strategies to quickly become competitive—for example, by entering niche markets that appreciate higher sustainability performance at the same product quality. A further factor that can enhance the competitiveness of new sustainable ventures is policy change in relation to sustainability targets—for example, a carbon tax or a ban on single-use plastic can boost the competitiveness of many biobased products. Therefore, sustainable entrepreneurs need to anticipate and adapt to such policy changes without entirely relying on them when making business plans.

The management of limited resources is needed just as much when creating new sustainable ventures as it is for ventures without a sustainability mission. While sustainable valorization of biomass and the marketing of biobased products require close engagement with the enabling mechanisms of cascading biomass use, managing limited resources involves handling supporting conditions to adapt them to the new venture. For example, ensuring sufficient funding of the right type is an important factor for sustainable entrepreneurs (Demirel & Danisman, 2019), as is hiring and managing a team, networking with relevant partners, and taking action when necessary.

5 | DISCUSSION

Our study examined (1) how entrepreneurial opportunities emerge in the bioeconomy context and (2) what skills and competencies

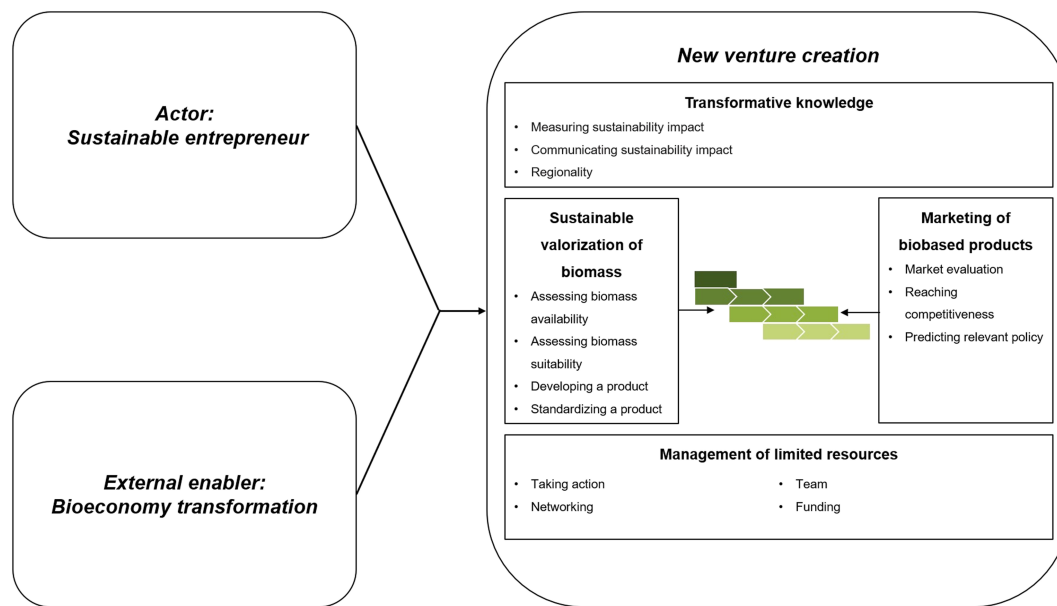


FIGURE 3 Model of new venture creation in the bioeconomy

sustainable entrepreneurs need to act on such opportunities. Consequently, we proposed a model of the individual–opportunity nexus that conceptualizes the bioeconomy transformation as an external enabler of entrepreneurial activity. Our findings link SE competencies and knowledge to the entrepreneurial processes of opportunity identification, evaluation, and exploitation, which represents the core of entrepreneurship research.

Our study contributes to the existing literature in three ways. First, we extend the frameworks that describe SE skills and competencies and show that such skills are sector-specific. Second, the EE framework substantiates our understanding of SE in the bioeconomy context. More specifically, we show that SE helps the transformation toward sustainable development and that the envisioned transformation enables and facilitates SE. Third, our EE framework opens avenues for future research on transformation and innovation policy.

5.1 | Extending SE skills and competencies frameworks

Our findings are in line with the previously developed competence frameworks (Biberhofer et al., 2019; Lans et al., 2014; Ploum et al., 2018). Competencies related to transformative knowledge (Urmetzer et al., 2018) encompass what has been previously described as system-thinking competence and normative competence (Biberhofer et al., 2019; Ploum et al., 2018). Furthermore, the management of limited resources overlaps with strategic management and action competence, interpersonal competence, and embracing diversity and interdisciplinary competence (Biberhofer et al., 2019; Ploum et al., 2018).

However, the competencies related to the dimensions of sustainable valorization of biomass and the marketing of biobased products

are unique to the bioeconomy context, which shows that SE skills and competencies are sector-specific. Previous studies have argued that SE drivers (Argade et al., 2021; Jensen et al., 2020; Jolink & Niesten, 2015; Niemann et al., 2020; Schaltegger & Wagner, 2011) as well as sustainable business models (Bocken et al., 2014) can be context-specific. Moreover, bioeconomy-specific factors influence sustainable entrepreneurs' business-strategy choices (Urbaniec et al., 2022). The same applies to entrepreneurial skills and competencies: As prior research on entrepreneurship education has shown, they can be context-specific (Thomassen et al., 2020). The identification of bioeconomy-specific SE competencies means they can be integrated into entrepreneurship education programs to improve opportunity-recognition patterns (Baron, 2006), which can positively influence sustainable entrepreneurs' business performances (Teruel-Sánchez et al., 2021).

5.2 | The bioeconomy transformation as an external enablers of SE

Although SE theory is being developed, research on SE in the bioeconomy context is relatively rare and limited to emphasizing the importance of entrepreneurship for the bioeconomy transition instead of describing SE's micro-foundations (Kuckertz et al., 2020). By conceptualizing the individual–opportunity nexus for the bioeconomy context, we take up a core concept in entrepreneurship research and create a solid foundation for a better understanding of SE in relation to a specific setting (Welter, 2011), namely the bioeconomy transformation.

Moreover, we show that entrepreneurial activity is a phenomenon that can be externally enabled by an envisioned bioeconomy transformation. In the literature, SE has been widely acknowledged

as an important factor in the transformation toward sustainable development in general (Horne et al., 2020; Johnson & Schaltegger, 2020; Schaltegger et al., 2018) and toward the bioeconomy in particular (Kuckertz et al., 2020). Bioeconomy strategies worldwide approach entrepreneurship as a driver of the desired transformation toward the bioeconomy (Kuckertz, 2020). In fact, entrepreneurship is needed to develop innovations and technologies to reduce greenhouse gas emissions (Leendertse et al., 2021) and successfully transform the current fossil-based economies into bioeconomies (Bröring et al., 2020; Lokko et al., 2018). Sustainable entrepreneurs push incumbents toward more sustainable activities (Hockerts & Wüstenhagen, 2010), which can subsequently lead to sustainability transformations of whole industries (Bohnsack et al., 2020; Hockerts & Wüstenhagen, 2010).

Finally, conceptualizing the bioeconomy transformation as an external enabler reveals that SE and the bioeconomy transformation mutually enable each other and share a bi-directional relationship. Our proposed EE framework describes the micro-foundations of this enabling relationship in detail, thus opening new avenues for the design of transformation strategies that account for this bidirectional enabling relationship.

5.3 | Making the EE framework useful for transformation and innovation policy

So far, the rationale behind entrepreneurship policy in the bioeconomy strategies of many governments has been to support entrepreneurial ecosystems and entrepreneurs in their endeavors to implement the governments' envisioned bioeconomy transformations (Kuckertz et al., 2020). However, conceptualizing the bioeconomy transformation as an external enabler implies that governments can foster entrepreneurship via their bioeconomy strategies in more ways than simply introducing direct support measures. In fact, policy makers can envision the bioeconomy transformation and design policies in a way that enables entrepreneurship and leaves space for entrepreneurial ventures to contribute to the envisioned transformation.

Davidsson et al. (2020) discussed the EE framework's potential as an analytic tool for policy designers: On the one hand, the EE framework can help assess the likely consequences of societal changes for entrepreneurial activity. On the other hand, it can guide regulatory design changes to stimulate entrepreneurial activity. Indeed, for the bioeconomy context, previous research has shown that, for example, innovation policies are less effective when they do not address sufficient biomass availability (Maes & Passel, 2019). This issue also came up in our interviews.

Therefore, we propose understanding entrepreneurship, especially SE, as something that can be enabled by suitably designed transformation and innovation policies. Mazzucato (2018) coined the term mission-oriented innovation policies for tackling "grand societal challenges." These mission-oriented innovation policies require the creation of new markets instead of "fixing" the existing markets that are unable to tackle—or may even be the cause of—the "grand challenges"

(Mazzucato, 2016). We believe that the EE of entrepreneurship can be a useful means of supplementing mission-oriented innovation policy and of conceptualizing and explaining the role of entrepreneurship in such innovation policy. We believe that this finding opens a promising avenue for future research and contributes to the discourse on suitable policy for fostering SE (Genus, 2021).

In conclusion, we propose understanding the bioeconomy transformation as an external enabler of sustainable entrepreneurial activity. By conceptualizing the individual–opportunity nexus for the bioeconomy context based on the EE framework, we have shown that to make use of the opportunities for entrepreneurial activity provided by the bioeconomy transformation, bioeconomy entrepreneurs need transformative knowledge and competencies related to sustainable valorization of biomass, the marketing of biobased products, and managing limited resources. Furthermore, we propose that conceiving SE as something that can be enabled externally opens new ways of understanding SE's role in the transformation toward sustainable development and the design of innovation policy targeting this transformation.

ACKNOWLEDGMENTS

This paper results from the University of Hohenheim's "Innovation, Entrepreneurship, and Finance (INEF)" research area. We acknowledge Erasmus+ funding by the European Union for the project "Fostering Entrepreneurship for the BioEconomy (FOEBE)." Furthermore, we appreciate the research assistance by Melvin Rohn.

AUTHOR CONTRIBUTIONS

SH: Conceptualization, formal analysis, investigation, data curation, writing – original draft, visualization, project administration. AK: Conceptualization, validation, resources, writing – review & editing, supervision.

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How to cite this article: Hinderer, S., & Kuckertz, A. (2022).

The bioeconomy transformation as an external enabler of sustainable entrepreneurship. *Business Strategy and the Environment*, 31(7), 2947–2963. <https://doi.org/10.1002/bse.3056>

APPENDIX A: INTERVIEW GUIDELINES

My research aims to understand the challenges faced by sustainability-oriented bioeconomy firms when starting up. The research is part of an EU-funded Erasmus + project called Fostering Entrepreneurship for the BioEconomy (FOEBE) and is associated with the European Bioeconomy University, an alliance of six European universities involved in bioeconomy research and education.

- Can you please introduce yourself? Who are you?
 - Educational background?
 - Professional experience?
- What is your startups business model?
 - Value proposition:
 - What is your product/service?
 - What are your customer segments?
 - How do you manage customer relationships for those customer segments?
 - Value creation and delivery
 - What are your key activities? (Which technology do you use to process biomass?)
- What are your key resources? (What kind of biomass do you process?)
- Who are your key partners?
- What are your distribution channels?
- Value capture
 - What is your cost structure?
 - What are your revenue streams?
- Can you please describe your process of starting up? From your first idea until today?
- What challenges have you been confronted with along the way?
 - Have you faced challenges regarding ...
 - ... funding?
 - ... sales and business development?
 - ... product development?
 - ... growth/scalability?
 - ... cashflow/liquidity?
 - ... human resources planning/recruitment?
- Have you developed any specific strategies for managing these challenges?
- Did I forget to ask something during the course of this interview that you regard as important in the context of my research aim?

APPENDIX B: REPRESENTATIVE QUOTATIONS FOR THE DIMENSION OF TRANSFORMATIVE KNOWLEDGE

Second-order theme	Representative quotations for <i>transformative knowledge</i>
Measuring sustainability impact	<p>“But if I look at the bioeconomy, then what I feel is like, okay, in the end, we want to make the bioeconomy work with residues. And thats going to be tricky too, because if you use virgin resources, then theres always plenty. But if you use the residues, then youre dependent on one partner, and youre dependent on the quality of the stream, and youre also, its really important that you show whats your impact. So its going to be for us important, as we perform the LCA [life-cycle analysis], that we communicate the environmental benefits of using our product.” (Interview 7)</p> <p>“They must have the certificate, FSC or BFC, anyhow, but it must be certified somehow. All customers, buyers are requiring certified raw material.” (Interview 1)</p>
Communicating sustainability impact	<p>“The packaging must be sustainable, the product must be sustainable. It has to be as regional as possible, as organic as possible, preferably not from corporations or whatever, then its just extremely expensive at the end. And then you have to communicate the whole thing so that the consumer understands why he is now paying three euros for his package instead of one. So thats an extreme challenge.” (Interview 10)</p> <p>And I think thats tricky because that means you have such a drive to make a difference, but to actually make the difference, you cannot be 100% perfect at once. And to communicate that clearly and to still keep people aligned with your vision, and thats, I think, very tiring and very difficult.” (Interview 7)</p> <p>“We do lack this marketing aspect and often the view from the outside. (...) every time weve tried—Even in a pitch and so on—To explain our product, it was maybe a bit too scientific and not enough on the point that people understood it or wanted to understand it. And thats where we had to, I guess, work very hard to just recognize that, how were trying to sell our product, and just explain it.” (Interview 3)</p>
Regionality	<p>“We tried for a long time to find someone who could do the complete product, but there is hardly anyone. (...) so we decided to do it ourselves, even though its more expensive, even though its more time-consuming, even though the machines always break down at some point. We are the only ones in Austria who do it. There is no one else in Austria who makes chewing gum. We just wanted to have regional and local production.” (Interview 10)</p> <p>“When were looking at that localised model, the idea that we go to a project place and we say, okay, who can construct it here? Who can manage the aquaculture here or grow the aquaculture here? I think thats a barrier to scalability because its not like if were manufacturing all the units ourselves, you can buy economies of scale, if you produce a lot, you can reduce the cost of it. The costs may always be different depending on the inputs of the place in which youre going. And we would like to have an impact on the local economy.” (Interview 6)</p> <p>“(...) that also supports the production in remote areas because that saves the transport costs when calorific value is higher. So per ton of transported material, you get more energy transported. It supports, in a way, the production in remote areas like Siberia.” (Interview 1)</p> <p>“And I think that our process has the potential to enable local production, and thats also a really cool factor. Even though sometimes, in the end, if you look at the environmental analysis, transportation costs are actually not often contributing as much to the final impact. But I like the idea that we can enable local production.” (Interview 7)</p>

APPENDIX C: REPRESENTATIVE QUOTATIONS FOR THE DIMENSION OF SUSTAINABLE VALORIZATION OF BIOMASS

Second-order theme	Representative quotations for <i>sustainable valorization of biomass</i>
Assessing biomass availability	<p>“There is a company that is cutting trees for the new roads or new area for buildings—So when you have trees that are close to the road. Theyre cutting trees because they need wider space. They are cutting this, and normally they are milling this for dust, for nothing. (...) this is very useful for me, to use this kind of material, which nobody [is] interested in.” (Interview 2)</p> <p>“We are a processor of fruit stones, and these fruit stones have been a waste product in the juice and fruit industry in general. (...) we have focused on stone fruit, such as apricot, cherry, and plum pits, and they are disposed of in huge quantities every year.” (Interview 5)</p>
Assessing biomass suitability	<p>“(…) many people think: ‘Yes, you can get a sidestream like that for free.’ No, of course they want to earn a bit of money with it, and the fact that they have to process it—Such as drying it—Means that our raw materials are also significantly more expensive than mainstream raw materials, such as potato starch or cornmeal or others.” (Interview 3)</p>
Developing a product	<p>“And then, of course, there is the research, which none of us has actually learned. Well, none of us has really done research on a grand scale, and we really had to teach ourselves that. Also, of course, in a very pragmatic environment that must not cost a lot and where none of the professors will help either, but that really has to be home grown.” (Interview 5)</p> <p>“So what we are really doing, and this is perhaps our scientific background again, is that we are already doing research projects on this, that we are saying: ‘What is the agriculture of the future? What is also biodiversity, species diversity, and agroecosystem of the future?’ And we are trying to say in cooperation projects with other research institutions or also industry partners, ‘what will an agricultural system look like in the future?’ And cant we somehow now, because we recognize every single little plant, say for once that you really specifically leave weeds there as well. Maybe they dont have a high damage potential, they dont have to be removed.” (Interview 4)</p>
Standardizing a product	<p>“Our key milestone right now, its developing the prototype further, but mainly to work toward a patent. And thats very important because we have some bigger American competitors. And, yeah, if they start filing a lawsuit in your direction, then youre dead. So you need to be protected.” (Interview 7)</p> <p>“The big challenge for me is to move this design prototype to production that is [made] by a group of 10 people, not me. I am doing this with minimum waste of wood and the minimum waste of some house of production, so the big challenge for me is to move this production to some small factory and keep quality.” (Interview 2)</p>

APPENDIX D: REPRESENTATIVE QUOTATIONS FOR THE DIMENSION OF MARKETING OF BIOBASED PRODUCTS

Second-order theme Representative quotations for *marketing of biobased products*

Market evaluation	<p>“We have to reach this market because there is a larger demand, they can sell it for a price, which is more interesting for us. So it was a good thing to begin with the market and not with the process.” (Interview 8)</p> <p>“Check your market before you start your business. So take the facts about the market potential. There's so much of this thing going around at the moment about any sustainability or climate change, or you name it. (...) but that's not the proof that there will be a market for your business. Lesson learnt is that check your market, and check it again and not think so much about the subsidies or what the politicians are talking or papers are writing. Because the market is what really defines if your company is going to survive. There must be demand.” (Interview 1)</p> <p>“We noticed that when we went out in public and gave presentations to more and more biogas plant operators, people weren't beating down our doors like we expected. We even have great results, we have such a, for us, great product. Something is not right.” (Interview 9)</p> <p>“I think mycelium has the potential to be a new type of material on its own. And it doesn't need to be an alternative to animal-derived products or whatever. I think it will grow in its own niche. So that's a bit more difficult because then you are developing new markets.” (Interview 7)</p>
Reaching competitiveness	<p>“At the beginning, we thought that because of all the environmental aspects, we can sell it more expensively than the alternative. But we understand that because we discussed with a lot of different customers, we understand that the price is more important than the environmental aspects.” (Interview 8)</p> <p>“And accordingly, we are also very high at the moment in our manufacturing costs, which again also affects the RRP [recommended retail price] in the store we propose, so we are in [supermarkets] for 1.99 [euros] for a 50 gram package. That is, of course, in terms of chips seen already quite high, in terms of such protein chips seen again exactly what the others also offer, so there is also often 50 grams for two euros.” (Interview 3)</p>
Predicting relevant policy	<p>“And we were told that time that there will be a radical change. OK, it's also a little bit big picture because in 2015 when we started, the cost of CO₂ ton was close to 30 euros per ton. And then it went down to seven or eight euros per ton, which made fossil coal really the cheapest fuel in Europe. Only now the cost of CO₂ emissions are growing and going up. As I told you, no serious actions anywhere to replace fossil coal by some renewables.” (Interview 1)</p> <p>“We also focused on the Nutri-score because we were able to achieve our A well, which can then also really be a selling point—At the moment it is not yet mandatory, but we strongly assume that it will then really be mandatory in one, two, three years, and then we will of course have a starting advantage over others.” (Interview 3)</p>

APPENDIX E: REPRESENTATIVE QUOTATIONS FOR THE DIMENSION OF MANAGEMENT OF LIMITED RESOURCES

Second-order theme	Representative quotations for <i>management of limited resources</i>
Funding	<p>“Ever since I started paying people, the burn rate is so high that I feel like to know that in three months you have no money. I mean, that's too short to get funding, actually. But yeah, we have to make it work because I was tired of waiting or tired to go slow and our competitors go fast.” (Interview 7)</p> <p>“So to the funding in general, who says that it is not a challenge has not [tried to get funding] yet ... Either it is really given to him, or he has not yet intensively pursued it himself. (...) that is always a challenge! Until we found an investor, (...) six-to-nine months went by. Nevertheless, the topic is socially interesting as well as economically.” (Interview 4)</p> <p>“And subsidies, I mean, subsidies are for projects like ours, large hardware that potentially has a great impact, but just need some funding that isn't crippling in terms of what you give up in order to receive it. Subsidies are a good fit.” (Interview 6)</p>
Networking	<p>“(…) by having market companions, we legitimize ourselves, you know what I mean, that just shows the interest is there, the potential is there, the market is there. And if I'm the only one doing it now for the next and the last 20 years, then the demand can't be that great. From that point of view, it's definitely great.” (Interview 10)</p> <p>“We actually had a project in a university course, where it was about investigating one's own idea further for a semester. And that's where I met my 'co-founder', my first 'co-founder', (...) and that's where we started the project, so to speak. Yes, the project then became a company, and we have now taken on a wide variety of roles.” (Interview 5)</p>
Taking action	<p>“We are already, as I said, food technologists, and accordingly it is most fun for us to actually create products. And that is completely missing right now. So it's really just a lot of different things right now that actually have nothing to do with our original studies, and you have to kind of dig into it without ever having learned it.” (Interview 3)</p> <p>“(…) of course, the number one topic is always firefighting. So, if there really is a problem somewhere, that you can deal with it as quickly as possible in order to avoid damage or perhaps also to simply solve this problem or find a better solution to it—That is definitely a point.” (Interview 5)</p>
Team	<p>“Where we definitely invested a lot of time is in the team. Until we have put together a proper team—I don't mean until we have put together a proper team, but until we have found all the key technical people and people who match the philosophy in terms of orientation and mentality—That is still not complete. It's an ongoing process, but it's definitely taken a lot of time. But it's definitely worth investing the time.” (Interview 4)</p> <p>“(…) because circular economy always has a technical part or at least a focus on maybe eliminating food or raw materials, but this economic side must also always be added because it must, of course, be economical in the long term, the whole thing must be economically sustainable, and we have noticed that this is often lacking in technical people. So, it really needs the combination of technology and economy that it can really take shape, I would say now.” (Interview 5)</p>