Circular business model experimentation: Demystifying assumptions

Demystifying assumptions

Konietzko, Jan; Baldassarre, Brian; Brown, Phil; Bocken, Nancy; Hultink, Erik Jan

DOI
10.1016/j.jclepro.2020.122596

Publication date
2020

Document Version
Accepted author manuscript

Published in
Journal of Cleaner Production

ACCEPTED VERSION

(Wordcount: 9065)

CIRCULAR BUSINESS MODEL EXPERIMENTATION: DEMYSTIFYING ASSUMPTIONS

Jan Konietzko[a], Brian Baldassarre[a], Phil Brown[a], Nancy Bocken[ab], Erik Jan Hultink[a]

[a] Delft University of Technology, Landbergstraat 15, 2628 CE Delft, Netherlands; j.c.konietzko@tudelft.nl, B.R.Baldassarre@tudelft.nl, P.D.Brown@tudelft.nl, N.M.P.Bocken@tudelft.nl, H.J.Hultink@tudelft.nl

[b] International Institute for Industrial Environmental Economics (IIIEE), Lund University, Tegnérsplatsen 4, Lund, Sweden; nancy.bocken@iiiee.lu.se

Corresponding author: Jan Konietzko, j.c.konietzko@tudelft.nl, Tel.: +4915756013100

PLEASE CITE AS:

Konietzko, J.; Baldassarre, B.; Brown, P.; Bocken, N.; Hultink, E.J. Circular business model experimentation: Demystifying assumptions. *J. Clean. Prod.* **2020**, 122596.

ABSTRACT

Circular business model experiments may help firms transition towards a circular economy. Little is known about how the participants of experimentation – entrepreneurs, intrapreneurs, innovation managers – develop and test their assumptions during the experimentation process to achieve more circular outcomes. Using a design-science approach, we investigate this process and develop principles to improve it. This is done during three workshops in different contexts: an innovation festival with 14 early-stage circular startups, a workshop with a health technology incumbent, and a workshop with six growth-oriented startups. We find that analyzing their available means – what they find important and prefer to happen (part of their identity), what they know (their skills and knowledge), and whom they know (their social network) – helps to understand how the participants develop and test their assumptions. We show how the mindset and awareness of the participants impact how much attention they pay to the circularity potential of their envisioned circular business models. Based on these insights, we propose a set of principles to prepare the innovation participants for experimentation, and to increase their ability to reflect on their circularity assumptions. Future research is needed to further grow our understanding of the types of principles that can guide meaningful experimentations towards a circular economy.

Keywords: Business model, Business model innovation, Circular economy, Lean Startup, Effectuation, Experimentation, Sustainability

1. INTRODUCTION

Firms are in need of methods and approaches to innovate their business models towards a circular economy (Blomsma and Brennan, 2017). In a circular economy, firms maximize the value of the material resources and minimize the overall resource use, waste, pollution and emissions that are associated with their business activities (Geissdoerfer et al., 2017). Designing and conducting business model experiments – small-scale and cost-effective ways to test the underlying theories and hypotheses about new business models – has become a promising approach to innovate towards a circular economy (Antikainen et al., 2017a; Bocken et al., 2019; Weissbrod and Bocken, 2017).

Most existing research on circular business model experimentation has used approaches that operationalize the 'The Lean Startup' (Ries, 2011), a popular approach in entrepreneurship practice (Antikainen et al., 2017a; Bocken et al., 2019; Bocken et al., 2017; Bocken et al., 2018; Weissbrod and Bocken, 2017). This research has shown that experimentation can help speed up action and decision-making towards sustainability in organizations. It has also revealed that the decision-making process during experimentation may be more opportunistic and messy than originally intended (Bocken et al., 2017). Participants often make intuitive judgements and decisions (Foss et al., 2019), rather than rely on the decision criteria of the experiment designs (Bocken et al., 2019). It also appears that the term experimentation may lead participants to adopt a more 'scientific' language, but not necessarily a more rigorous approach to innovation (Weissbrod and Bocken, 2017). In addition, collecting and analyzing data during experimentation may result in unexpected events and surprises that require fast changes of the experiment designs (Antikainen et al., 2017b). Some have suggested that approaches like The Lean Startup fail to guide how the participants can develop and test their hypotheses; that is, how they develop the underlying theory of value about their proposed business models (Felin et al., 2019). Moreover, it appears that there is a gap between the intended formality of experimentation approaches like The Lean Startup (Ries, 2011), and the opportunistic and intuitive nature of how decisions are made during experimentation (Felin et al., 2019; Foss et al., 2019; Sarasvathy, 2001).

The goal of this study is two-fold: first, we aim to better understand how the participants develop and test their assumptions during circular business model experimentation; second, we use this understanding to propose a set of principles that can help improve the process. This is guided by two research questions: *How do the participants develop and test their assumptions during circular business model experimentation? How can a better understanding of this help improve the process?* Through a design-science approach for entrepreneurship research (Romme and Reymen, 2018), we design and validate contexts and principles for circular business model experimentation. This is done in the course of three different workshops: a circular oriented innovation event with 14 novice student entrepreneurs; an incumbent from the health technology sector and nine participants; and six growth-oriented startups as part of a startup program, with twelve participants.

We find that analyzing their available means – what they find important and prefer to happen (part of their identity), what they know (their skills and knowledge), and whom they know (their social network) – helps to understand how the participants develop and test their

assumptions during experimentation. These available means (Sarasvathy, 2001) influence what they focus on – whether they focus on, for example, the desirability of a value proposition, or the contribution of an envisioned business model to a circular economy. Based on these insights, we propose a set of principles to improve the process. This includes, for instance, the importance of recognizing the available means of the participants, and to prepare them if these means are not conducive to more circular outcomes. Future research can use and further develop these principles to better understand how to experiment with new business models towards a circular economy.

2. CONCEPTUAL BACKGROUND

In this section, we introduce the key concepts of this study: the business model, business model experiments, and circular business model experiments. This leads us to identify the research gap and the intended contribution.

2.1 BUSINESS MODEL

A business model helps to describe, investigate, and design how firms do business (Baden-Fuller and Morgan, 2010; Magretta, 2002). It contains three essential elements: the value proposition (what a firm offers and to whom), value creation and delivery (how it creates and delivers the offering), and value capture (how it earns money and other forms of value with it) (Bocken and Short, 2016; Richardson, 2008). From a design perspective, these three elements can be desirable, feasible and viable (Brown, 2008; Calabretta et al., 2016). Desirability is a property of the value proposition: how desirable a value proposition is to, for example, intended users, customers or investors. Feasibility is a property of value creation and delivery: how feasible it is to organize the needed activities and resources to create and deliver the value proposition. Viability is a property of value capture: how the business model can generate enough revenue to sustain the cost of creating and delivering the value proposition (Figure 1) (Richardson 2008; Bocken and Short 2016; Calabretta et al. 2016). We refer to the properties desirability, feasibility and viability because they are useful in the context of experimentation, i.e. they can be tested. For example, you can test the desirability of a value proposition, or the viability of a business model, to inform the right of course of action during the design process (Simon, 1996).

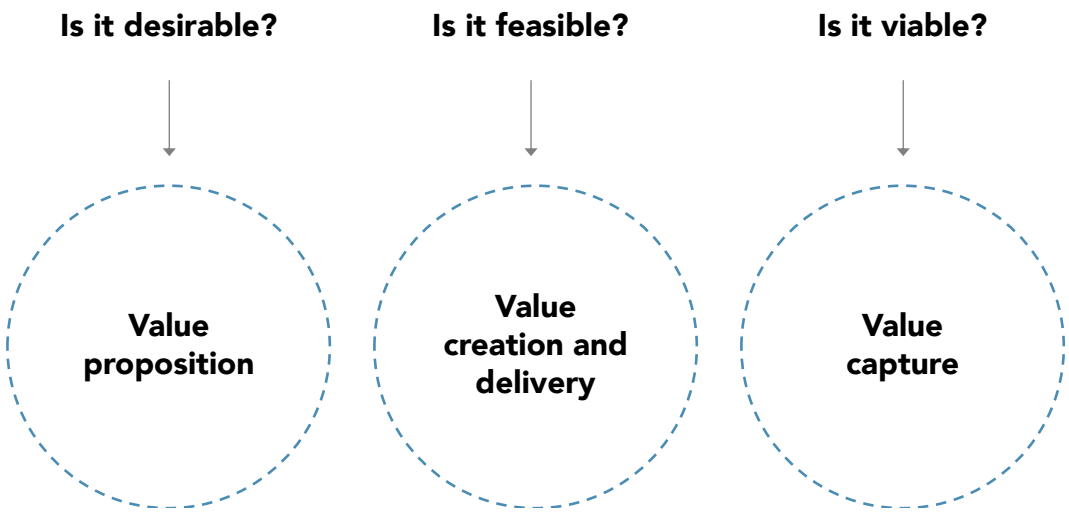


Figure 1 – The business model (based on Richardson 2008; Bocken and Short 2016; Calabretta et al. 2016)

2.2. BUSINESS MODEL EXPERIMENTS

Business model experiments can be defined as small-scale and cost-effective ways to test the underlying theories and hypotheses about the desirability, feasibility and viability of a new business model (based on Calabretta et al., 2016; Camuffo et al., 2019; Osterwalder et al., 2014; Ries, 2011). Most business model experiments with start-ups and established business can be characterized as 'quasi-experiments' (Cook and Campbell, 1979), as they cannot be easily controlled in a business environment (Bocken et al., 2018; Weissbrod & Bocken, 2017). Experiments influence the experience and perception of entrepreneurs and organizations, and help to form more accurate beliefs and expectations about the 'right' course of action (Felin and Zenger, 2009). An experimental approach to business modelling makes it more likely that entrepreneurs scrutinize the profitability of their ideas, that they pivot faster, and that they increase their chances of high returns (Camuffo et al., 2019). Business model experiments are important because from the outset, the probabilities of success are not known (Knight, 1921), and the potential outcome is unclear (Kerr et al., 2014). These conditions characterize business modelling as a highly uncertain process. Investors therefore tend to value experimentation, because they enable them to fund startups and new business models in stages. For each stage, experiments have to reveal new data that inform the quality and likely profitability of the new business model. The benefit of experimentation in a situation of high uncertainty is two-fold: one can assess projects without having to invest large amounts of money upfront, and pursue projects without having to go for an all-or-nothing bet (Kerr et al., 2014).

One of the most popular approaches for business model experimentation is The Lean Startup (Blank, 2013; Felin et al., 2019; Osterwalder et al., 2014; Ries, 2011). This approach proposes a formalized build-measure-learn cycle to conduct business model experiments: *build* a 'minimum viable product', *measure* how interested potential customers are in this product, and use the results to *learn* whether an idea may work or not (Ries, 2011). This is often done by using workshop material like 'experiment cards' that define the hypothesis, the test to verify the hypothesis, the metric to measure success, and the decision criteria to further pursue an idea (Osterwalder et al., 2014). Examples of such experiments include

conversational interviews through a quasi-ethnographic approach with a potential partner, or online A/B tests, where two landing pages with different value propositions are tested to understand which element of the value proposition may gain more traction among potential customers (Camuffo et al., 2019; Osterwalder et al., 2014).

A further important design approach to business model experimentation is effectuation (Sarasvathy, 2008). Effectuation is a theory of entrepreneurship that explains how expert entrepreneurs develop successful ventures. According to this theory, entrepreneurs start with a given set of means (what they find important and prefer to happen, what they know, and whom they know) to prototype new business models. These prototypes are shaped through continuous negotiations to get the commitment and buy-in from external parties (Sarasvathy, 2008). Effectuation poses that an expert entrepreneur follows four principles in this process of new venture creation: 1) An entrepreneur only invests what she can afford to lose. This principle reflects an iterative and step-by-step approach, which is similar to The Lean Startup; 2) she seeks strategic alliances that provide commitment and buy-in for her ideas. This stresses the importance of securing commitment and is also similar to the Lean Startup approach, where direct payments or sign-ups are possible signs of commitment of an experiment; 3) she captures value from unexpected situations. This principle emphasizes the spontaneous and messy nature of the entrepreneurial process; 4) she controls an unpredictable future by building a safe network of supporting stakeholders. This highlights the need for a strong social network to sustain and grow the business (Sarasvathy, 2001). Based on these principles, we pose that effectuation can be seen as an intuitive and less formalized approach to experimentation (Bocken and Antikainen, 2019).

2.3. CIRCULAR BUSINESS MODEL EXPERIMENTS

Business model experiments have been increasingly conducted in the context of a circular economy. Most of the existing research on circular business model experimentation has used The Lean Startup as an underlying approach (see, for example, Antikainen et al., 2017b; Bocken et al., 2018; Weissbrod and Bocken, 2017). A circular economy seeks to maximize the value of products, components and material over time, and minimize the overall resource use, associated emissions, waste and pollution (Geissdoerfer et al., 2017). Firms can experiment with four inter-related circular strategies (Bocken and Antikainen, 2019): they can narrow (use less material and energy during design, production, use and end-of-life), slow (use products and components longer), close (use wasted products, components and materials again) and regenerate (use non-toxic materials, renewable energy and manage critical ecosystem services) the material and energy flows associated with their business activities (Figure 2) (Konietzko et al., 2020a). Firms can use these strategies to develop new circular business models, and then test how these business models can contribute to circularity – in parallel to how desirable, feasible and viable they are. The goal is to develop new business models that provide superior customer value, and that help to maximize the value of products, components and materials over time, and to minimize the overall associated resource use, waste, emissions and pollution (Bocken and Antikainen, 2019).

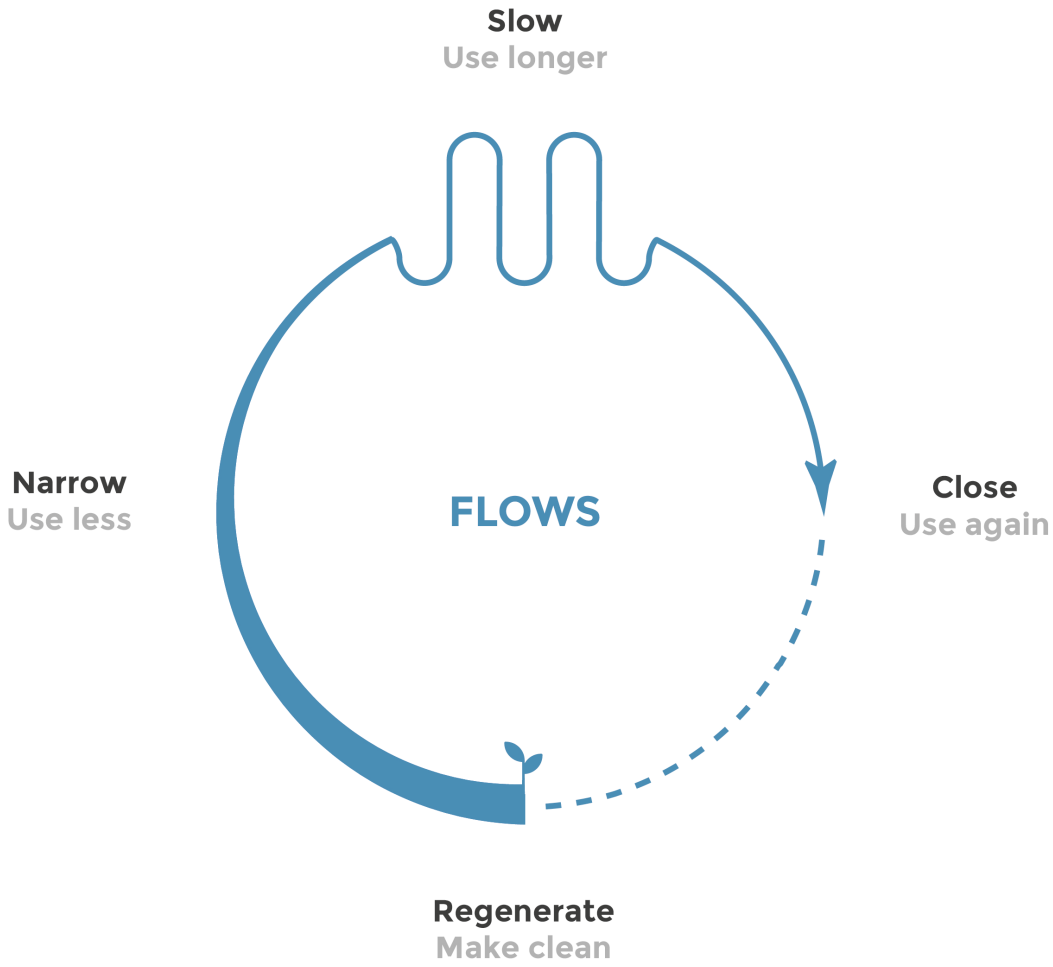


Figure 2 – A circular economy: narrow, slow, close and regenerate material and energy flows (Konietzko et al., 2020a)

The existing research on this topic has shown that circular business model experimentation can help stimulate innovation and action towards circularity in organizations. It has the potential to promote an iterative 'getting things done' attitude among the participants (Bocken et al., 2017). On a spectrum of what can be done to learn about new business models, experiments are situated between fast learning (e.g., paper sketches, interviews) and slow learning (e.g., business plans, pilots, market studies) (Bocken and Antikainen, 2019). The success of circular business model experiments may depend on the following: a careful selection of the participants (Bocken et al., 2017), internal buy-in from staff and top level management, experimentation capabilities within the organization, as well as commitment from relevant partners who can develop complementary products and services (Antikainen et al., 2017b; Weissbrod and Bocken, 2017). It is also necessary to incorporate 'circularity checks', to make sure that experimentation is geared towards higher circularity (Bocken et al., 2018).

These 'circularity checks' are especially important. This is because circularity – a situation in which the value of products, components and materials is maximized, and in which the overall resource use, waste, emissions and pollution are minimized – is a property of a higher-order system, rather than a property of an individual product or business model (Konietzko et al., 2020a). For example, a car may be made lighter and more durable. But if the overall number

of cars on the road increases and the cars stand idle 95 % of the time, then the overall resource use, waste and emissions are not minimized. Providing a car sharing service, that is, changing the business model, may decrease the overall number of cars on the road. But if the cars are powered with fossil fuels and still have an idle time of 60 %, then the overall resource use, emissions and waste are not minimized. Instead of focusing on products and business models only, circularity thus needs to be approached from an ecosystem perspective.

From a circular ecosystem perspective, a firm can experiment with a set of complementary products, services and business models (Konietzko et al., 2020b). For instance, to maximize the capacity use of cars, a car sharing provider may try and connect business-to-business fleet operators that have previously had their own fleets. The same cars can also be made accessible for end users through a joint car sharing platform, as well as for the staff of the involved companies through a corporate car sharing program. The car sharing provider can then work together with a local energy provider and make sure the cars are fueled with renewable energy. The batteries in these cars, once they are below a certain quality threshold, can then be installed in office spaces to provide heating and thereby prolong their useful lives. As this example illustrates, several different actors need to be activated and aligned to jointly contribute to circularity as a collective outcome.

Due to the complexity of this collaborative and uncertain process, understanding how circularity can be achieved is a major challenge (Brown et al., 2019). It is therefore important that the innovation participants develop accurate assumptions about the circularity potential of their envisioned business models. In other words, they need to develop a critical and reflective mindset, not only with regards to how desirable something is for the user, but also with regards to the circularity of their proposed circular business models. To develop such a mindset, it is first necessary to understand how the participants develop and test their assumptions during experimentation – to then see how this process can be organized to achieve more circular outcomes.

2.4. RESEARCH GAP AND CONTRIBUTION

Previous research on circular business model experimentation has found that structured experimentation may often be more messy and opportunistic than originally intended (Bocken et al., 2017). There seems to be a gap between the intended formality of quasi-experimental approaches like The Lean Startup and the intuitive and opportunistic nature of judgements during experimentation (Felin et al., 2019; Foss et al., 2019). In particular, it is not clear how the participants build their hypotheses and underlying theories of value about the possible desirability, viability, feasibility of their envisioned circular business models, as well as their contribution to circularity (Felin et al., 2019). Our study addresses this gap about the process of developing and testing assumptions during circular business model experimentation. It is important to better understand this, because it influences the circularity outcomes of the envisioned business models. In this study, we therefore want to better understand how the participants develop and test their assumptions during circular business model experimentation; and to use this understanding to develop principles that can help improve it.

3. METHOD

This study applies a design science framework for entrepreneurship research (Romme and Reymen, 2018) to research how the participants develop and test their assumptions during circular business model experimentation (Figure 3). The purpose of the framework is to develop knowledge that is both theoretically sound and practically useful (Denyer et al., 2008; Van de Ven, 2007). The research output from this study is a better understanding of how the participants develop and test their assumptions during this process, and a set of principles to improve it. The framework serves to specify how to design and validate this research output within a continuous research cycle: how to create and evaluate (together: design), and how to generalize and justify it (together: validation). It is important to note that these four steps are complementary and researchers may jump from one step to another.

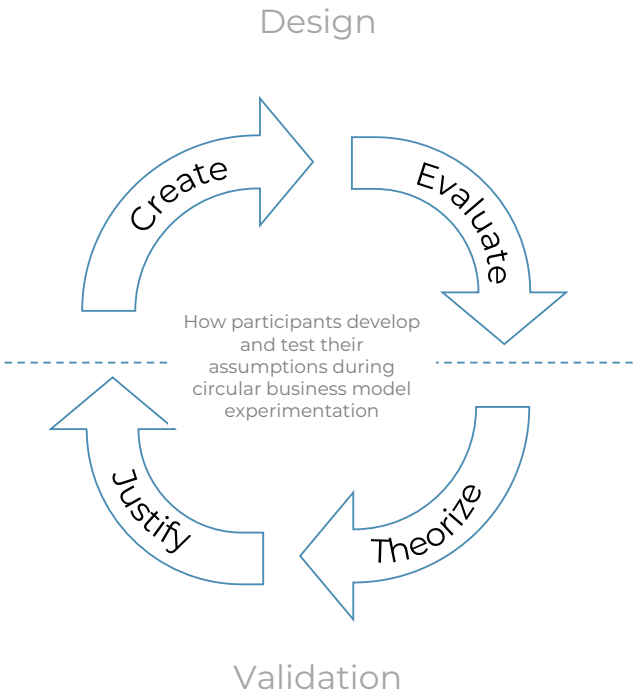


Figure 3 – A framework to design and research workshop formats for circular business model experiments (Romme and Reymen, 2018)

3.1. DESIGN AND VALIDATE THE CONTEXTS OF EXPERIMENTATION

The first step of the study is to design and validate the contexts of circular business model experimentation. This is done through three workshops. Each workshop represents a different context of experimentation: one with sustainability-minded novice entrepreneurs, one with an incumbent firm that communicates ambitions to innovate towards a circular economy, and one with more experienced and sustainability-minded entrepreneurs. Each one in turn:

1) The first workshop was created for a ten-day innovation event for the circular economy in the North of The Netherlands (event name: DORP). The event hosted 14 early-stage start-up ideas for a circular economy, posed by novice entrepreneurs, and around 70 participants (most of them master students with design or engineering backgrounds) who formed groups around the 14 ideas. Examples of the startups include two architects who developed a modular furniture set that can be playfully turned into twelve different furniture types (e.g., armchair, coffee table, bench, office table or display); a start-up that has developed packaging material based on wood from certified forests in Sweden; a startup that develops a service model to replace disposable plates and cutlery with reusable ones; a firm that turns old, otherwise wasted bread into beverages.
2) The second workshop was created for nine participants from a Dutch incumbent in the health technology sector. The goal of the company is to become a circular economy pioneer and it has a defined circular economy strategy that needs to be implemented by the different sections of its business portfolio. The participants of the workshop focused on a business section that sought to turn a consumer product from a sales into a product-as-a-service business model.
3) The third workshop was created for 12 participants from six circular oriented startups during an accelerator program of the Impact Hub in Zurich, Switzerland. Examples of these startups include a firm that rescues left-over yields from farm lands and turns them into a vegetable box subscription, a firm that provides baby clothing as a service, and an online platform where users can share everyday goods.

3.2. DESIGN AND VALIDATE PRINCIPLES FOR EXPERIMENTATION

The first set of principles, applied within a workshop format, was designed for and validated during a ten-day innovation event for the circular economy in the North of The Netherlands. The initial set of principles was derived from the business literature and based on what has been used in earlier research on circular business model experimentation. The principles included: 1) formulate the assumptions you have about how and why an envisioned business model may work in reality (Ries, 2011), 2) test your assumptions early outside of your organization's boundaries, rather than plan thoroughly 'at the desk' (Blank, 2013), 3) iterate fast and several times through the build-measure-learn cycle (Ries, 2011). These principles were instantiated in the form of a list of possible test methods and instructions (Table 1) (retrieved from Schuit et al. 2017; Bocken et al. 2018; Ries 2011; Osterwalder et al. 2014), as well as test cards to formulate assumptions and a validation graph to prioritize the tests (Figure 4) (based on Osterwalder et al., 2014).

Method	**Instruction**
Brainstorming	Get a multi-disciplinary team and perspectives from outside the company and sit together to brainstorm about the assumption
Conversational interview	Interview the person of interest to learn from them
Online A/B test; split-test experiments	Get budget for ad-campaign and a content-writer for ads, write ads and launch them on e.g. Facebook, Google, etc. Make different versions to test different assumptions
Booklet interview	Make a product/service booklet and hand it to a potential customer to get feedback
Ethnographic observation	Get into the field where your customer/user/partner is and observe what they do and how they do things

Creative session with users	Invite users/customers/partners who are able and willing to discuss openly to have a creative session about the problem/potential solution
Moderated online discussion with community members	Find an online forum about your problem and learn from posts, start a discussion about the learning you are trying to gain
Co-create session with stakeholders	Find a location and schedule a meet-up with relevant stakeholders to co-create a solution
Rapid service prototyping/minimum viable product	Make a first physical and/or digital prototype (e.g. paper mock-up, web landing page, cardboard mock-up), get in front of customers and learn from their reactions
Landing page with Video + option to sign up	Make a short video where you pitch your idea and create a landing page with a call to action (e.g. sign up for the newsletter, early ordering option for product, etc.)
Concierge MVP: "fake it until you make it"	Try to fake the product/service through human actions, help the customer out right away without having any product, improvise
Field experiment	Find a test ground (e.g. a festival), user group, and create an experiment set-up
Wizard of Oz testing	Take humans who can provide the service that you want to provide instead of machines to gain learning

Table 1 - List of possible tests that was available for the first workshop (retrieved from Schuit et al. 2017; Bocken et al. 2018; Ries 2011; Osterwalder et al. 2014)

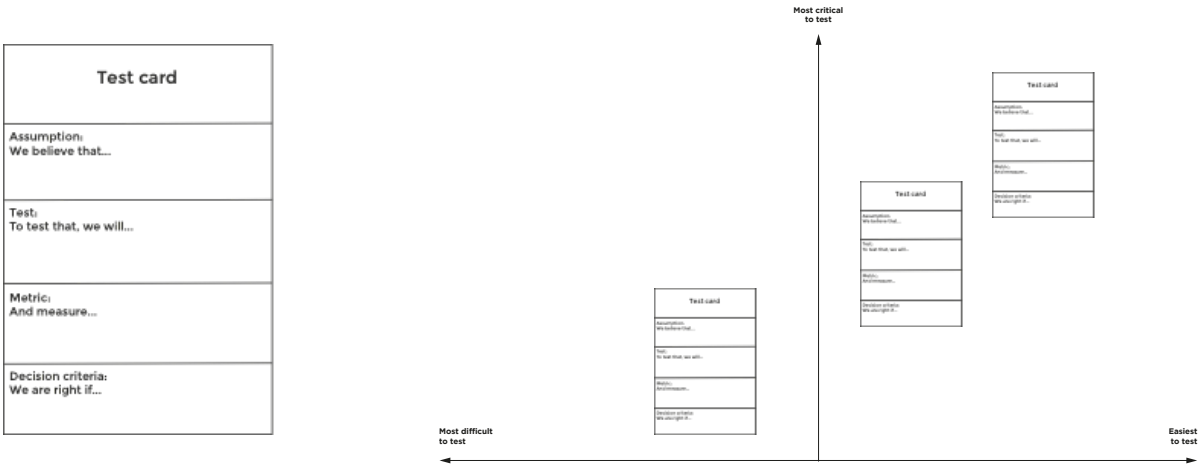


Figure 4. Initial test cards and the validation graph. Based on Osterwalder et al. (2014)

During the event, the principles were presented in 30 minutes to the participants. The presentation triggered the group to discuss and reflect on their envisioned business models in terms of assumptions. Questions we discussed included: *"what would need to be true for your ideas to work in reality?"; "What are your assumptions?"* We then went through the test cards and explained how the participants could use them to develop and test their assumptions and define tests, metrics and decision criteria. We also introduced the list of tests they could do and discussed some examples. The validation graph was presented as a way to plot and prioritize the test cards according to what they would perceive as easiest and most critical to test. After the presentation, they spread out into groups to use the provided material in a two-hour workshop session.

3.2.1. Data collection

In the course of the three workshops, we collected different types of data. During the first workshop, we conducted semi-structured interviews (see Appendix A for an overview of the

interview questions we asked) (Patton, 2002), made notes to capture observations about the use of the workshop material, made photos of the filled material and followed up with some of the participants later on to see what experiments the participants eventually ran, and what they learned from them. In the second and third workshops, we made notes during the workshops, took photos of the filled-in material and content from post-its, documented discussions among the researchers about the workshop afterwards, and for the third workshop collected a filled-in survey half a year later about the progress and activities since the workshop. Furthermore, each workshop was evaluated by collecting and analyzing data on its user acceptance. This was measured in terms of its ease-of-use and perceived usefulness (Davis, 1989). The participants filled in feedback forms after each session (Appendix B). The form stated the intended purpose of the workshop (first version: *"understand the assumptions underlying a business idea, and to decide how to test them, and what to test first"*) and then posed two statements: *"The material is useful to address the stated purpose above."* and *"The material is easy to use."* Each statement could be rated with a Likert scale from 1 to 7 (1= fully disagree, 7=fully agree, after the first round we adapted this to 1-5). We also encouraged the participants to explain their rating through written feedback. The results were used to validate the ease-of-use and usefulness of the principles that we proposed for the workshops. Table 2 provides an overview of the collected data during each of the three workshops.

Collected data	Total length/amount of data
First workshop	
Feedback forms	35 filled in forms
Audio/video recorded session	115 minutes
Observations from researchers	145 minutes/4 pages
One interview after session about how easy to use the session materials were (10 minutes each)	60 minutes
Discussions among researchers about the session	60 minutes/two pages
Filled-in test cards	8 test cards
One interview during the testing	55 minutes
Observations from researcher during testing	120 minutes/4 pages
One interview after the testing per group	40 minutes
Second workshop	
Feedback forms	9 filled in forms
Photos from post-its and generated ideas and strategies	22 photos
Observations from researchers in the form of notes	180 minutes, one page summary
Discussions among researchers about the session	30 minutes, one page summary
Filled-in workshop material	9 filled in templates
Third workshop	
Feedback forms	6 filled in forms
Observations from researcher in the form of notes	180 minutes, one page summary
Filled-in workshop material	6 filled in templates
Company survey after half a year	6 filled in surveys

Table 2 – List of collected data from the three workshops

3.2.2. Data analysis

The data was coded using a mix of descriptive (describe what is being said), In Vivo (which uses the actual language used by participants and reflects the emotionality of the situation) and process coding (observing actions performed by the participants) (Saldaña, 2013). We coded the data according to the three available means of an effectual decision-making logic (Sarasvathy, 2001): what they find important (part of their identity), what they know (their

skills and knowledge), and whom they know (their social network). The codes were developed through an iterative coding process that revealed how these available means influenced how the participants developed and tested their assumptions. For example, one important code for the category 'what they find important' is 'the business model property', sub-divided into the codes desirability, viability and feasibility. This coding enabled us to analyze what business model property the participants found important to investigate. Figure 5 shows the coding structure that resulted from the data analysis. The identified codes within the three categories are not meant to be exhaustive. Rather, they show important elements that had an influence on how the participants developed and tested their assumptions throughout the three workshops. The resulting coding structure informs the theoretical research output of this study, which is detailed in the results section 4.1.

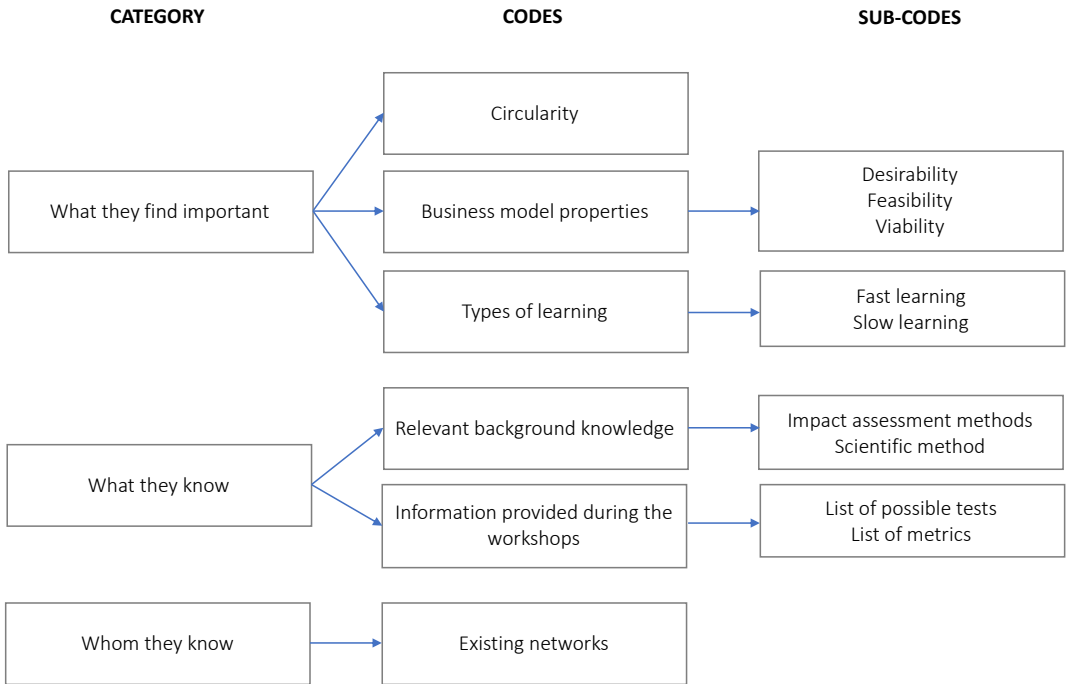


Figure 5 – The resulting coding structure from the data analysis

In addition to the coding structure, each workshop was evaluated through the feedback forms. We did this to ensure the practical relevance of the principles that we applied throughout this research. The feedback form gave us insights on the usefulness and ease of use of the proposed principles, and served to develop an evaluated set of principles as a practical research output of this study. This output is detailed in the results sections 4.2.

4. RESULTS

We present the results in terms of theoretical and practical relevance. The first section (4.1.) presents the theoretical results that address the first research question: how the participants develop and test their assumptions during circular business model experimentation. The second section (4.2.) presents the practical outcomes, in the form of principles, that address the second question: how a better understanding of this can help improve the process.

4.1. HOW THE PARTICIPANTS DEVELOP AND TEST THEIR ASSUMPTIONS

We find that the participants develop and test their assumptions in terms of what they need to find out about their envisioned business models, and how they can find it out. The decision-making logic that underlies this process is influenced by their available means: what they find important (part of their identity), what they know (their skills and knowledge), and whom they know (their social network).

4.1.1. What they find important

The participants decided what they needed to find out and how they could find it out based on what they found important. This related to, for example, if they found *circularity* important to investigate, the *business model property* (desirability, feasibility, viability), or if they prefer *fast and/or slow learning*.

Circularity: Across all three workshops, experimenting with and investigating circularity was not considered most important. This was in spite of the fact that the workshops were about developing business models for a circular economy. In the first workshop, when prompted, the participants found it difficult to pinpoint which sustainability problem they were trying to address. They stated: "*We are assuming it is more sustainable than current offers"; "it's not crucial right now".* In the second workshop, circularity was defined by the whole organization under the term 'circular revenues'. A product-as-a-service model, for example, would count as 'circular revenues'. When asked to reflect on why product-as-a-service models were circular, the participants noted down: *"subscription enables refurbishment, personalized offering (buy only what you need), access over ownership"*; *"obvious"*; *"first step to service concept, investigate need for update and refurbishment*"; *"we remain the owner, closed loop logistics, reusing basic materials, owning materials"*; *"service model, we own the product".* Only one participant, who had previously worked with environmental life cycle assessments, questioned: *"Is refurbishing more circular and better for the environment?"* In the third workshop, one participant investigated the circularity potential of their idea by asking how many use cycles they could achieve with their baby clothing-as-a-service model, compared to the current average number of cycles. Apart from that, most of the participants assumed that their solutions are 'better' for the environment compared to existing offerings, and did not find it important to better investigate this assumption. They only seriously investigated and documented their assumed circularity or environmental improvements when they had to fill in a dossier for a startup award. These findings show that 'circularity checks' are influenced by whether participants find circularity relevant and important to their process.

The business model properties: The most important business model properties are desirability, feasibility and viability. Most participants in the first workshop focused on the desirability of their envisioned business models. They paid a lot of attention on how they could sell their products and services, and what value they would provide for their customers. The other two workshops were more mixed, with attention on several business model properties and no clear preference for either of them. For example, in the second workshop, one participant with a user-centered approach was interested in the desirability of a refurbished product. Another participant wanted to investigate how feasible their idea was

in terms of the hygiene of returned products. Yet another was curious to investigate if the lower price point would get a customer to buy a refurbished product. In the third context, most of the participants considered it important to focus their experiments on the desirability and viability. Table 3 contains a selection of quotes that show which business model properties the participants found important to investigate. They illustrate which business model property the participants found important.

	Workshop 1	**Workshop 2**	**Workshop 3**
Desirability	*"Are they potentially interested?"* *"Will they understand our story?"* *"Will they like our product?"* *"How to make the product more appealing for potential customers?"* *"How can we turn our service into an experience for the customer?"* *"What is a good name for this product?"*	*"What drives the consumer? What do they want in refurbished products?"* *"How many of these products does an average customer buy in a lifetime?"* *"What is the customer perception of refurbished products?"* *"What is our target group?"*	*"How many of our customers are willing to pay for this offering?"* *"How many will sign up if we advertise this service?"*
Viability	*"What are people willing to pay?"*	*"Does the price drive the decision to buy a refurbished product?"*	*"What are our costs?"* *"How can we price our service?"* *"Is this financially viable?"*
Feasibility	*"Does the service model work?"* *"What are the challenges of delivering this service?"*	*"Will reused products be bio-contaminated?"* *"Can the product be fully modular?"* *"Does refurbishment affect product safety?"* *"Will the customers clean the product themselves?"*	*"How can we get our users to act autonomously?"*

Table 3 – Questions that the participants in the three workshops found important to investigate

Fast and/or slow learning: Fast learning during business model innovation can be gained, for example, via paper sketches, quick interviews or try-outs. Slow learning happens through, for instance, business plans, market studies or pilots. In the first context, most participants found fast learning more important than slow learning. This is likely related to the context of the workshop: an innovation festival in the summer with prototyping facilities and a near-by music festival to test the prototypes. The founder of a service model for reusable plates, for example, noted that they were *"just trying stuff quickly"* to see what worked and what did not. Another participant noted during the testing: *"you just change things quickly and see what happens".* In the second and third workshops, participants had mixed preferences for both fast and slow learning. In the second one, some participants were eager to act and

organize a fast experiment and interviews with some of their employees in their office building. Another participant preferred to conduct a life cycle assessment on the possible environmental impacts of selling refurbished products. In the third workshop, some found it important to make an elaborate cost calculation to design and plan an experiment. Another participant decided to focus on quick changes to the website design, search engine optimization and customer journey optimization. These examples illustrate that whether the participants prefer fast and/or slow learning influences what they want to test and how.

4.1.2. What they know

The participants determined what they had to find out and how based on what they knew. This related to, for example, their *relevant background knowledge* or the *provided information during the workshops*.

Relevant background knowledge: Relevant background knowledge refers to the skills and knowledge that the participants bring into the experimentation process. In the first workshop, most of the participants did not follow the suggested quasi-experiment approach and rigorously collected data, but instead wanted to learn by doing. For example, the leader of a startup that offered multifunctional furniture noted that there is *"no need to be too rigid about things".* The team was simply looking to get customers to sign up. This can be partly explained by a lack of background knowledge of and experience in experiment design. A team member from the service model for reusable plates concluded from the testing that the service model did not really work, because the plates did not meet the aesthetic requirements of their client. Again, this was not based on a carefully designed experiment, but came from the direct, intuitive experience. In the second workshop, the participant who had previously worked with Life Cycle Assessments suggested to conduct such an assessment for the envisioned business model around refurbished products. Another participant with a design background focused on the user-centered methods for value proposition design. In the third workshop, some participants with a mechanics background focused on the feasibility of repairing a certain number of products as part of their envisioned business model. Others with a marketing background focused on how they could optimize their online channels to attract more customers. As these examples show, the background knowledge has an influence on what the participants want to test and how they want to test it.

Provided information during the workshops: This refers to the information that the participants receive during the experimentation, for example in the form of concepts and methods that they can use. In the first workshop, the list with available testing methods contributed to the participant knowledge about how to test their assumptions. During the testing, they used methods such as conversational interviews to understand how much potential customers were willing to pay, how well they understood the story, ethnographic observations to see how users interacted with their prototypes, A/B tests to understand preferences, competitor comparisons, and 'Wizard-of-Oz' testing (*"fake it until you make it").* In the second workshop, the participants used the provided information to formulate why customers would be interested in their proposed solutions, or what they could do to test their assumptions. In the third workshop, participants were triggered to select a concrete metric that they wanted to improve through their experiments. They used this information to concretize their ideas for experiments. For example, one startup that wanted to monetize

left-over yields from farm lands decided to measure buy-in from a potential retail partner through an experiment to launch a weekly veggie box subscription (*"Will they accept the price offering?"*). Another startup that provided baby clothing as a service defined the circularity metric 'number of use cycles' to measure its comparative impact in the baby clothing market (where there is generally one use cycle). This shows that the available information during experimentation influences what the participants want to test and how.

4.1.3. Whom they know

The participants decided what they had to find out and how based on whom they knew. This related to, for example, their *existing network.*

Existing network: This refers to how the social network of the participants can help support the experimentation process. In the first workshop, the existing network had an influence on how the participants prioritized what assumptions to test. For example, the founder of one startup noted that she could *"easily take this one to our partner and discuss*". Towards the end of the workshop session, another participant noted that *"it is interesting that a lot if this really boils down to the network".* Whom they knew had an influence on how they prioritized what assumptions to test first. One participant noted that "*there is actually someone here we can ask about this*". The founder of the startup that offered multifunctional furniture noted that it was easy to find out how their furniture adds value to the brand experience of their potential clients: she already had a client who used their furniture for this purpose, and could go and ask them for more details about how the furniture added value. The existing network also helped get further contacts and buy-in from external parties. For example, the startup with the service model for reusable plates got buy-in to conduct a full experiment at the festival from the event organizers, because they believed in the idea. They also helped to connect the startup to the food providers on the festival to co-organize the experiment. In the second workshop, existing retail partners were mentioned as potential places to conduct an experiment to try and offer a product-as-a-service model. Also internal staff was mentioned as a potential test group to conduct some early experiments around user acceptance for a refurbished product. Similarly, in the third workshop, participants designed experiments together with existing retail, distribution or promotion partners. It appears that the network determines which assumptions the participants prioritize, because tapping into the existing network is immediately actionable. It requires comparatively low efforts to set up experiments and to get the needed information. This shows that the existing network can influence how participants want to test their assumptions during circular business model experimentation.

4.2. PRINCIPLES TO HELP IMPROVE CIRCULAR BUSINESS MODEL EXPERIMENTATION

We have shown how analyzing their available means – what they find important, what they know and whom they know – can help to better understand how the participants develop and test their assumptions during circular business model experimentation. Based on this better understanding, we propose a set of principles for *before* experimentation, and a set of principles for *during* experimentation.

4.2.1. Before experimentation

Recognize what the participants find important: to ensure that circular business model experiments aim at higher circularity (or lower environmental impact), it is important to involve participants who care about circularity and the minimizing of environmental impact. The more the participants think it is important to ensure that their envisioned business models reduce environmental impact and resource use, the more likely they are to be critical and scrutinize their assumptions about the circularity of the proposed ideas. If some of the participants do not think that circularity is relevant and important, then they need to be supported in developing a stronger awareness about it.

Recognize what the participants know: to ensure that circular business model experiments aim at higher circularity, it is important to involve participants who know about the environmental impacts of their business activities, and how this impact – and the potential impact of the proposed business model changes – can be measured using concrete metrics. In addition, the more the participants know how to apply the principles of the experimental method (how to formulate a hypothesis or theory, and how to test it rigorously), the more likely they are to avoid false negatives: where they disconfirm the potential of an opportunity where there is one; and false positives: where they confirm an opportunity where there is none.

Recognize who the participants know: to ensure that circular business model experiments aim at higher circularity (or lower environmental impact), it is important that the participants explore and develop a supportive network that can help inform and conduct the experiments. A supportive network can, for example, make the experiments more actionable (partners can provide space to experiment), more collaborative (partners can co-develop complementary products and services), more cost-effective to organize (known partners mean lower transaction cost because of existing ties), and more meaningful (knowledge partners can, for example, help assess the circularity of the experiments).

4.2.2. During experimentation

Formulate assumptions in terms of what you need to find out: in the first workshop, we proposed test cards and a validation graph to the participants as a way to develop and test their assumptions. The average rating of perceived usefulness was 4.8 (out of 7), and of ease-of-use 5.1 (out of 7). Many who provided a rating indicated that they did not use the methods (25%). The test card's ability to stimulate immediate action was limited. Thinking in terms of assumptions was often not perceived as helpful. As one participant pointed out: *"I feel like we don't end up anywhere if we point out all these assumptions".* Instead, the participants developed an intuitive alternative to the test cards to formulate their assumptions. They simply asked: *"what do we need to find out to see if this can work?"* In the second workshop, the participants used this technique to post their assumptions on a wall. This was perceived as a useful way to document the things they did not know and that they wanted to find out.

Prioritize assumptions in terms of what you can do right now, with what is available: the participants in the first workshop tried to answer their questions by looking at currently available means. One noted: *"the question is really what we can test here and now".* Another

participant commented that *"it is true that there is a lot that you can do, but it is also about what is it that you can do right now"*. In the second workshop, the prompts to document possible immediate actions (*"what can we do right now to find out?"*) were captured on post-its and collected on a wall. They provided an intuitive and easy-to-use way to generate a concrete action plan for the next experiment.

Define key metrics: in the second workshop, the metric of 'circular revenues' (e.g., revenue from a product-as-a-service model) was defined as a key metric to guide experimentation. In the third workshop, we asked for feedback on the usefulness and ease-of-use of using concrete metrics to guide circular business model experiments. These were perceived as useful (average rating of 4.25 out of 5) and moderately easy to use (3.5 of 5). The moderate rating on ease of use was because one team needed more time to define meaningful metrics, and another participant who had to leave earlier and could therefore not use the workshop material as intended. The use of circularity metrics prompted the participants to focus on one key metric that can help them specify how each action further grows the business and increases circularity. For example, one startup that developed a baby-clothing-as-a-service model focused on 'number of use cycles' as a circularity metric. They found that the subscription model may lead to six use cycles, compared to one cycle in the sales model. Another startup that developed a sharing platform for everyday goods measured the number of items on its platform and the number of times they have been rented out to make inferences about avoided sales of these items. The participants noted that defining metrics to guide their experiments helped to *"decide what to focus on"* and that *"it was very helpful to decide on goals for the coming time".*

5. DISCUSSION

This study makes two contributions to the existing research and practice of circular business model experimentation. First, to research, it adds an improved understanding of how the innovation participants – entrepreneurs, innovation managers, business managers, designers – develop and test their assumptions during the experimentation process. Second, for practice, it adds a set of principles – based on this improved understanding and the workshop evaluations – that can help to improve the experimentations. We discuss both contributions and the limitations of this study in the following sections.

5.1. CONTRIBUTION TO CIRCULAR BUSINESS MODEL EXPERIMENTATION RESEARCH

The findings from circular business model experimentation research show that the experimentation reality is less formal than what may be desirable according to The Lean Startup (Ries, 2011), confirming earlier findings on the application of Lean startup in the circular economy context (Bocken et al., 2017). In general, approaches like The Lean Startup lack an understanding of, and guidance on how the participants – entrepreneurs, innovation managers, business managers, designers – develop an underlying theory of value about their envisioned business models (Felin et al., 2019). In this study, we seek to contribute to a better understanding of this process. In particular, we show that their available means influence how the participants move through the experimentation process. Decisions on what to test, how to test it, and what to conclude from the tests are influenced by an effectual logic and behavior: what they find important (part of their identity), what they know (their skills and

knowledge) and whom they know (their social network) (Sarasvathy, 2008). This supports the findings from the circular business model experimentation literature (Bocken et al., 2017). It also fits with the understanding that the innovation process is often driven by subjective and intuitive judgements (Foss et al., 2019). It is therefore important to recognize this underlying process of developing and testing assumptions, to make the participants aware of it, and in turn to develop a more reflective and rigorous process.

It is important to highlight that these findings do not intend to discredit the merits of a more formalized approach to entrepreneurship. We are aware of earlier research that has demonstrated the potential positive influence of a more formal approach to business venturing (Camuffo et al., 2019). Rather, we argue that a better understanding of the subjective nature of decision-making during experimentation can help to make the process more rigorous. With regards to circularity, this relates to making sure that the participants have strong sustainability and circularity aspirations; that they have the skills and knowledge that are necessary to experiment towards circularity; and that they have a supportive network to achieve their aspirations. This adds to previous findings about the importance of carefully selecting the participants who join the efforts (Bocken et al., 2017). It is important to understand that they never enter into the process with a blank slate. Rather, they have a set of predetermined means – their identity, their skills and knowledge, and their social network – that influence it. We argue that recognizing and leveraging these means can help improve the process.

5.2. CONTRIBUTION TO CIRCULAR BUSINESS MODEL EXPERIMENTATION PRACTICE

The practical research output of this study is a set of principles that can help improve circular business model experimentation. The first three principles relate to the effectual logic and behavior of the participants before the process: what they find important, what they know and whom they know. Recognizing these elements can be used to compose stronger teams for experimentation. In particular, it can be used to identify participant profiles with useful capabilities, for example: a strong personal drive to innovate towards sustainability and a circular economy, good knowledge of the scientific method, an understanding of environmental impact assessments, and a network of supportive actors that can be used to support and widen the perspective of the process.

We also propose a set of principles for during experimentation. During experimentation, the participants can formulate their assumptions in terms of what they think they need to find out about their ideas. They can prioritize which assumptions to test by looking at what they can do right now, and whom they know who can support or who is needed for the inquiry process. The participants benefit from defining concrete metrics to guide their search process. This is to ensure an element of rigor and goal orientation within a largely effectual process. We provide an example set of metrics (Appendix C) that can be used as inspiration to find an appropriate metric. The search for an appropriate metric can be guided by questions such as: *how do we know if we are on the right track? What do we want to achieve? How do we measure progress?* We learned throughout the three workshops that defining a key metric for each experiment helps to focus the efforts, and that it helps to be clear about the intended outcome of an experiment. This is in line with earlier propositions for a metric-based approach to business model experimentation (Croll and Yoskovitz, 2013; Heikkilä et al.,

2016). It is important to highlight that metrics do not have to be quantitative. Sometimes, qualitative metrics are more meaningful, especially when a business model is new and has no prior history (Antikainen et al., 2017b). These principles need further research to understand when and how they can be used to experiment more successfully.

5.3. LIMITATIONS OF THIS STUDY

We highlight several limitations of this study. First, It is important to note that we conducted three workshops: two in the Netherlands and one in Switzerland; one with novice entrepreneurs, one with an incumbent and one with growth-oriented and more experienced entrepreneurs. This provides a solid data foundation, but is limited in terms of organizational (no mid-sized company, for example) and cultural richness (no emerging or developing country context). Second, there are potentially other ways to explain and describe the decision-making logic during business model experimentation. We found an effectual logic and behavior to be useful in this context. This does not mean that other theoretical frameworks may not also shed light on the underlying logic of how the participants form a theory of value about their envisioned business models. Third, the proposed principles need further testing and refining, especially with regards to the metrics. Previous research has collected a set of metrics to guide business model experimentation (Croll and Yoskovitz, 2013; Heikkilä et al., 2016). It is important to better understand how metrics can be used during circular business model experimentation, especially how they can help to conduct 'circularity checks' (Bocken et al., 2018).

6. CONCLUSION

This study has shown that analyzing their available means – what they find important, what they know, and whom they know – can help to better understand how the participants develop and test their assumptions during circular business model experimentation. We also showed how a better understanding of this underlying process can help improve it. In particular, *before* experimentation, it can help to form a strong circular oriented team with participants who care about circularity, know about it, and have a network of supporting stakeholders to explore circularity from an ecosystem perspective. Moreover, *during* experimentation, we propose that the participants can formulate their assumptions in terms of what they need to find out about their ideas, that they can prioritize what to test based on what they can do right now with what is available, and that they benefit from defining concrete metrics to guide their search process. Future research is needed to further increase our understanding of the experimentation process. In particular, it is important to further investigate, for example, how to compose effective experimentation teams, how to choose an appropriate metric for an experiment, and how to organize more inter-organizational business model experimentations for ecosystem level change towards sustainability and a circular economy.

REFERENCES

Antikainen, M., Aminoff, A., Kettunen, O., Sundqvist-Andberg, H., Paloheimo, H., 2017a. Circular economy business model innovation process – Case study, in: Smart Innovation, Systems and Technologies. https://doi.org/10.1007/978-3-319-57078-5_52

Antikainen, M., Aminoff, A., Paloheimo, H., Kettunen, O., 2017b. Designing circular business model experimentation - Case study. ISPIM Innov. Forum 1–14.

Baden-Fuller, C., Morgan, M.S., 2010. Business models as models. Long Range Plann. https://doi.org/10.1016/j.lrp.2010.02.005

Blank, S., 2013. The four steps to the epiphany, Fifth edit. ed. K&S.

Blomsma, F., Brennan, G., 2017. The Emergence of Circular Economy: A New Framing Around Prolonging Resource Productivity. J. Ind. Ecol. 21, 603–614. https://doi.org/10.1111/jiec.12603

Bocken, N., Miller, K., Weissbrod, I., Holgado, M., Evans, S., 2019. Slowing resource loops in the circular economy: An experimentation approach in fashion retail, in: Smart Innovation, Systems and Technologies. https://doi.org/10.1007/978-3-030-04290-5_17

Bocken, N., Schuit, C.S.C., Kraaijenhagen, C., 2018. Experimenting with a circular business model: Lessons from eight cases. Environ. Innov. Soc. Transitions.

Bocken, N.M.P., Antikainen, M., 2019. Circular business model experimentation: Concept and approaches, in: Smart Innovation, Systems and Technologies. https://doi.org/10.1007/978-3-030-04290-5_25

Bocken, N.M.P., Miller, K., Weissbrod, I., Holgado, M., Evans, S., 2017. Business model experimentation for circularity: Driving sustainability in a large international clothing retailer. Econ. Policy Energy Environ. https://doi.org/10.3280/EFE2017-001006

Bocken, N.M.P., Schuit, C.S.C., Kraaijenhagen, C., 2018. Experimenting with a circular business model: Lessons from eight cases. Environ. Innov. Soc. Transitions. https://doi.org/10.1016/j.eist.2018.02.001

Bocken, N.M.P., Short, S.W., 2016. Towards a sufficiency-driven business model: Experiences and opportunities. Environ. Innov. Soc. Transitions 18, 41–61. https://doi.org/10.1016/j.eist.2015.07.010

Brown, P., Bocken, N., Balkenende, R., Brown, P., Bocken, N., Balkenende, R., 2019. Why Do Companies Pursue Collaborative Circular Oriented Innovation? Sustainability 11, 635. https://doi.org/10.3390/su11030635

Brown, T., 2008. Design thinking. Harv. Bus. Rev. 86. https://doi.org/10.1145/2535915

Calabretta, G., Gemser, G., Karpen, I., 2016. Strategic Design: 8 Essential Practices Every Strategic Designer Must Master. BIS Publishers.

Camuffo, A., Cordova, A., Gambardella, A., Spina, C., 2019. A Scientific Approach to Entrepreneurial Decision Making: Evidence from a Randomized Control Trial. Manage. Sci. https://doi.org/10.1287/mnsc.2018.3249

Cook, T., Campbell, D., 1979. Quasi-Experimentation: Design and Analysis Issues for Field Settings. Houghton Mifflin Company, Boston.

Croll, A., Yoskovitz, B., 2013. Lean Analytics. O'Reilly Media Inc., Sebastopol.

Davis, F.D., 1989. Perceived Usefulness, Perceived Ease Of Use, And User Acceptance of Information Technology. MIS Q. 13, 319–40.

Denyer, D., Tranfield, D., Van Aken, J.E., 2008. Developing design propositions through research synthesis. Organ. Stud. https://doi.org/10.1177/0170840607088020

Felin, T., Gambardella, A., Stern, S., Zenger, T., 2019. Lean startup and the business model: Experimentation revisited. Long Range Plann. https://doi.org/10.1016/j.lrp.2019.06.002

Felin, T., Zenger, T.R., 2009. Entrepreneurs as theorists: on the origins of collective beliefs and novel strategies. Strateg. Entrep. J. https://doi.org/10.1002/sej.67

Foss, N.J., Klein, P.G., Bjørnskov, C., 2019. The Context of Entrepreneurial Judgment: Organizations, Markets, and Institutions. J. Manag. Stud.

https://doi.org/10.1111/joms.12428
Geissdoerfer, M., Savaget, P., Bocken, N.M.P., Hultink, E.J., 2017. The Circular Economy – A new sustainability paradigm? J. Clean. Prod. 143, 757–768. https://doi.org/10.1016/j.jclepro.2016.12.048
Heikkilä, M., Bouwman, H., Heikkilä, J., Solaimani, S., Janssen, W., 2016. Business model metrics: an open repository. Inf. Syst. E-bus. Manag. https://doi.org/10.1007/s10257-015-0286-3
Kerr, W.R., Nanda, R., Rhodes-Kropf, M., 2014. Entrepreneurship as experimentation. J. Econ. Perspect. https://doi.org/10.1257/jep.28.3.25
Knight, F.H., 1921. Risk, Uncertainty, and Profit. Houghton Mifflin, Boston.
Konietzko, J., Bocken, N., Hultink, E.J., 2020a. A Tool to Analyze, Ideate and Develop Circular Innovation Ecosystems. Sustainability 12, 417. https://doi.org/10.3390/su12010417
Konietzko, J., Bocken, N., Hultink, E.J., 2020b. Circular ecosystem innovation: An initial set of principles. J. Clean. Prod. 253, 119942. https://doi.org/10.1016/j.jclepro.2019.119942
Magretta, J., 2002. Why Business Models Matter. Harv. Bus. Rev. https://doi.org/10.1016/j.cub.2005.06.028
Osterwalder, A., Pigneur, Y., Bernarda, G., Smith, A., 2014. Value proposition design, Strategyzer series. https://doi.org/10.1017/CBO9781107415324.004
Patton, M.Q., 2002. Qualitative Research & evaluation methodos. SAGE Publ. https://doi.org/10.1037/a0033788
Richardson, J., 2008. The business model: an integrative framework for strategy execution. Strateg. Chang. 17, 133–144. https://doi.org/10.1002/jsc.821
Ries, E., 2011. The Lean Startup: How Today's Entrepreneurs Use Continuous Innovation to Create Radically Successful Businesses, Crown Business. https://doi.org/23
Romme, A.G.L., Reymen, I.M.M.J., 2018. Entrepreneurship at the interface of design and science: Toward an inclusive framework. J. Bus. Ventur. Insights 10. https://doi.org/10.1016/j.jbvi.2018.e00094
Saldaña, J., 2013. The Coding Manual for Qualitative Researchers, Sage Publication. https://doi.org/10.1109/TEST.2002.1041893
Sarasvathy, S.D., 2008. Effectuation - Elements of Entrepreneurial Expertise. Edward Elgar Publishing Limited.
Sarasvathy, S.D., 2001. Causation and effectuation: Toward a theoretical shift from economic inevitability to entrepreneurial contingency. Acad. Manag. Rev. 26, 243–263. https://doi.org/10.5465/AMR.2001.4378020
Schuit, C.S.C., Baldassarre, B., Bocken, N., 2017. Sustainable business model experimentation practices: evidence from three start-ups, in: Bakker, C., Mugge, R. (Eds.), Product Lifetimes and the Environment (PLATE) 2017 - Conference Proceedings. Delft University of Technology and iOS Press, Delft, pp. 370–376.
Simon, H.A., 1996. The sciences of the artificlal. MIT Press.
Van de Ven, A.H., 2007. Engaged scholarship: A guide for organizational and social research. Oxford Univ. Press 344. https://doi.org/10.1017/CBO9781107415324.004
Weissbrod, I., Bocken, N.M.P., 2017. Developing sustainable business experimentation capability – A case study. J. Clean. Prod. 142, 2663–2676. https://doi.org/10.1016/j.jclepro.2016.11.009

ACKNOWLEDGMENTS

This work was made possible by the Marie-Sklodowska-Curie Innovative Training Network "Circ€uit" - Circular European Economy Innovative Training Network, within the Horizon 2020 Programme of the European Commission (grant agreement number: 721909). The authors gratefully acknowledge the support of the European Commission and the contributions of partners in this project.

APPENDICES

APPENDIX A - INTERVIEW THEMES AND QUESTIONS FOR THE FIRST WORKSHOP

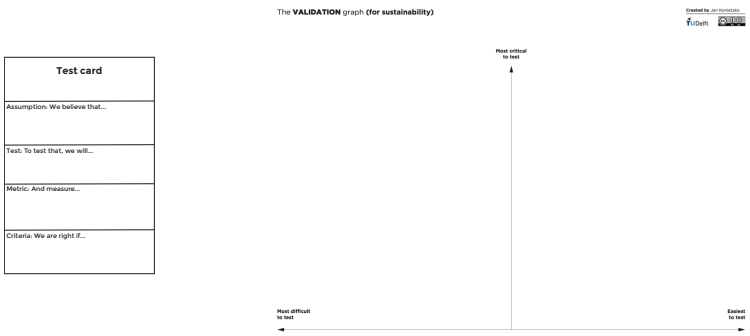
Interview	**Interview themes/questions**
One interview after session	**The workshop material:** 1) What are your assumptions? 2) How do you want to test them? 3) How are you going to measure this? 4) When do you know whether you are on the right track? **Reflection** 3) How helpful was it to think in terms of assumptions? 4) How did you formulate assumptions? 5) How did you prioritise them?
One interview during the testing	1) How is the testing going? 2) What are you testing? 3) What exactly are you measuring?
One interview after the testing	1) How did the testing go? 2) What have you tested? 3) What have you learned? 4) How does the testing experience help you move forward?

APPENDIX B – FEEDBACK FORM

Tool assessment form

You just used the **test cards** and the **validation graph** (see image below). Its purpose is to understand the assumptions underlying a business idea, and to decide how to test them, and what to test first.

Please quickly answer the following questions.



1. The tool is useful to address the purpose stated above.

	1	2	3	4	5	6	7	
Do not agree at all	○	○	○	○	○	○	○	Fully agree

Please explain your answer:

2. The tool is easy to use.

	1	2	3	4	5	6	7	
Do not agree at all	○	○	○	○	○	○	○	Fully agree

Please explain your answer:

3. Other remarks:

APPENDIX C –EXAMPLE METRICS FOR DESIRABILITY, VIABILITY AND CIRCULARITY

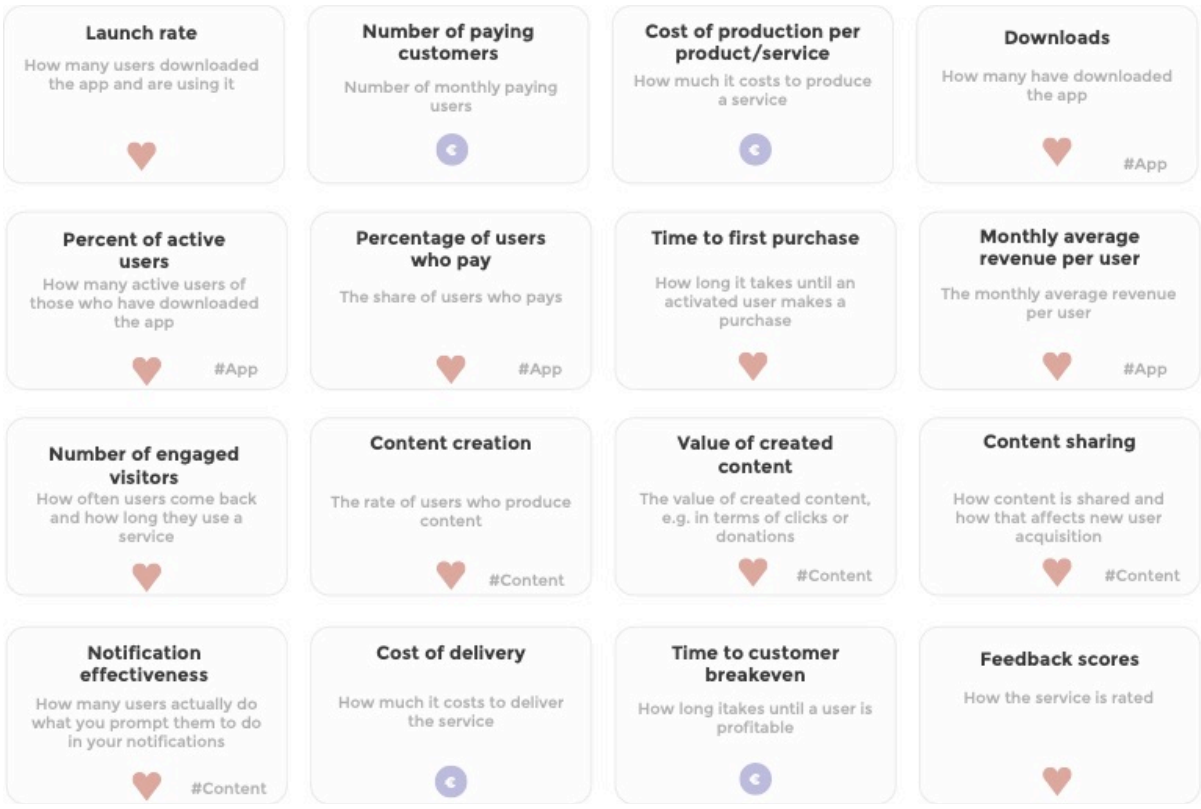


Figure 2 – Some examples of desirability and viability metrics used to trigger participants (based on Croll and Yoskovitz, 2013; Heikkilä et al., 2016).

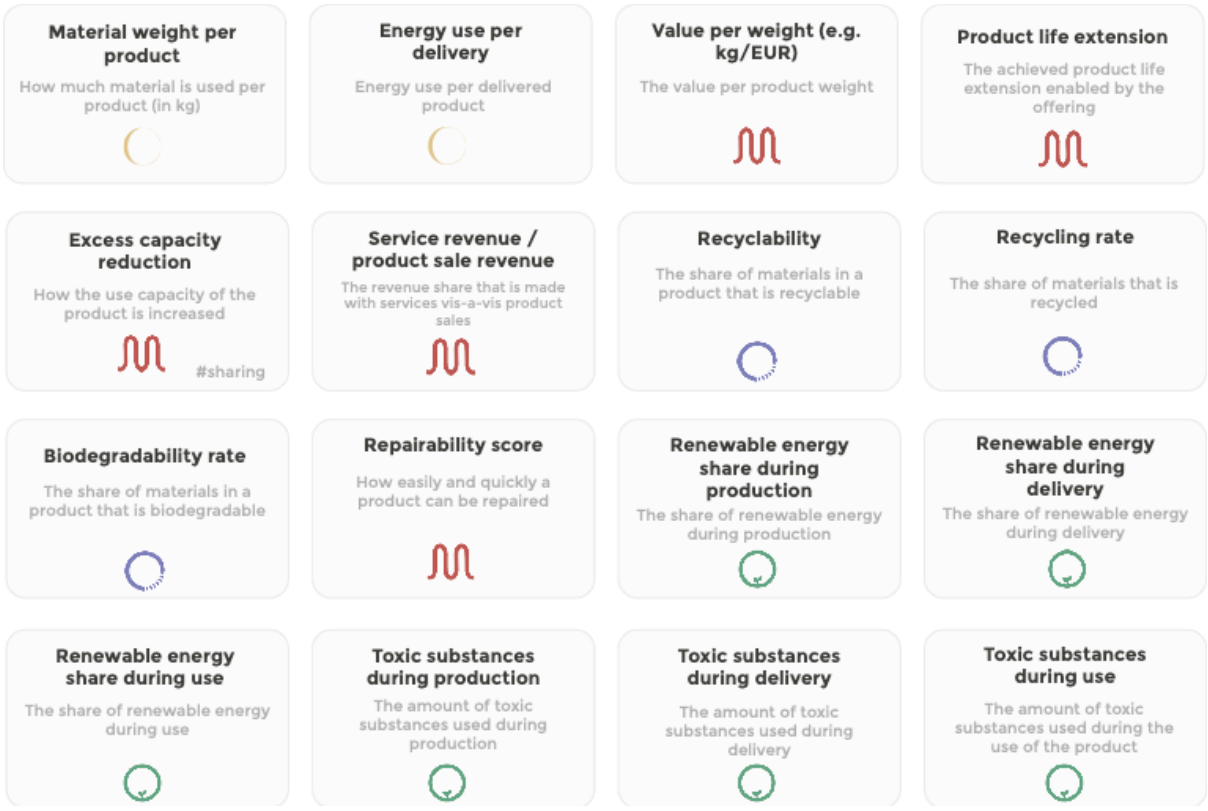


Figure 3 – Some examples of potential circularity metrics used to trigger participants (see Konietzko et al., 2020a for details).