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The effectiveness of involving users in digital innovation: Measuring the impact of living labs

Pieter Ballon[a,*], Miriam Van Hoed[b], Dimitri Schuurman[c]

[a] imec-SMIT, Vrije Universiteit Brussel, Pleinlaan 9, 1050 Brussels, Belgium
[b] IDEA Consult, Joseph II straat 40 B1, 1000 Brussels, Belgium
[c] imec-MICT, University of Ghent, Miriam Makebaplein 1, 9000 Gent, Belgium

1. Introduction

Innovation in digital products and services is often dependent on leveraging knowledge on a global scale, fostering an ecosystem of complementary artefacts and accounting for yet unknown uses and practices. For such reasons, it has become widely accepted that the inclusion of external stakeholders early on in the innovation process is an important source of competitive advantage for Information and Communication Technology (ICT) firms. Many succesful ICT companies are said to have adopted open R&D and open innovation strategies. The idea that users should also be included in this has been stressed by various scholars and practitioners, even though the degree to which this is feasible and effective, is still intensely debated. So-called 'living labs' are one of the most prominent tools to have been developed for such user-centric innovation of ICTs (von Hippel, 1988; Berker et al., 2005; Frissen and Van Lieshout, 2006; Gassman, 2006; Ståhlbröst, 2008; García-Guzmán et al., 2013).

Over the last two decades, a few thousands of organisations and initiatives that label themselves as 'living labs' have sprung up across the world. In parallel, several national and regional governments, as well as international bodies such as the European Union, have gradually introduced the moniker of 'living labs' into their innovation instrumentarium (Eriksson et al., 2005; Almirall et al., 2012; World Bank and ENoLL, 2014; Schuurman, 2015; Leminen et al., 2017). The concept of a living lab refers to the involvement of multiple stakeholders, including users, in the exploration, co-creation and evaluation of (usually ICT-related) innovations within a realistic setting (Dutilleul et al., 2010; Leminen et al., 2012; Ballon, 2015).

The aims of such labs are manifold: bring digital innovation processes and outcomes more in line with user preferences and practices, discover unexpected uses, identify potentially sound business and revenue models, stimulate cooperation between stakeholders, enable specific stakeholder groups to influence design features, increase acceptance, understand and tackle inhibiting factors, minimise failures, or study effects of introduction. As living lab initiatives proliferate, the question whether these aims are being reached, becomes indispensable (Følstad, 2008; Ståhlbröst, 2012).

However, studies indicate that there are several issues with regards to the current living labs movement. First of all, the notion of a living lab is used to describe a broad spectrum of activities and organisations, which results in conceptual unclarity and different perspectives on their theoretical basis (Leminen and Westerlund, 2016). Second, a recent study discovered 'mortality rates' of living labs associated to the European Network of Living Labs of at least 40% (Schuurman, 2015). Perhaps most problematic is the apparent lack of empirical, comparative studies on living labs to go beyond describing the phenomena or anchoring them to theoretical frameworks (Schuurman et al., 2016).

This paper first makes the point that the pragmatic, practice-oriented nature and overall heterogeneity of living lab initiatives until now have stood in the way of any thorough impact evaluation. Secondly, it discusses the applicability of impact assessment and evaluation principles and approaches to living labs. Finally, the results of the first systematic impact evaluation of a series of living lab projects are presented and analysed.

* Corresponding author.
E-mail addresses: pieter.ballon@vub.ac.be (P. Ballon), miriam.vanhoed@ideaconsult.be (M. Van Hoed), Dimitri.Schuurman@imec.be (D. Schuurman).

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2. Living lab environments and approaches

Besides earlier uses of the term mostly as research metaphor, the term 'living lab' in the context of innovation in real-life contexts was first associated with MIT's MediaLab in the late 1990s (Kidd et al., 1999; see also Schuurman, 2015; Leminen et al., 2017). Since then, interpretations and implementations of living labs have diverged considerably.

While MIT's William Mitchell regarded a living lab as a purpose-built set of rooms where the introduction of ICT innovations into (a simulation of) home life could be experimentally manipulated (Kidd et al., 1999), a range of European living labs, that sprung up during the first years of the 2000s, offered a fundamental reinterpretation. Inspired by earlier experiences with a.o. participatory design and social experiments with ICT since the 1970s, these labs aimed to study ICT usage in actual real-life habitats and promoted active co-creation with users of digital products and services (Niitamo et al., 2006; Ballon and Schuurman, 2015). Other divergences or unclarities have arisen as well, i.e. with the interpretation of living labs as primarily an *environment*, versus an *approach*.

In a living lab *environment*, the setting is such that innovative (usually ICT-related) products or services can be experienced within a context that closely resembles familiar circumstances (Følstad, 2008). This is driven by the notion that ICT innovation concerns not just technology but rather 'sociotechnical' arrangements of humans and machines embedded in social contexts, and therefore should be understood, designed and improved *in vivo* (Ratto, 2000). As indicated, this familiar context may take the shape of a controlled lab setting which mimics the day-to-day usage context, such as a purpose-built living room or hospital room, or it may be a real-world setting, such as a campus, an office building or an urban neighbourhood. The environments are selected and managed by living lab practitioners so as to allow the involvement of different types of stakeholders in innovation activities, the introduction of new technologies in realistic circumstances, the monitoring of their acceptance, usage and effects, and so on.

In terms of the organisational setting, a living lab environment often refers to a constellation that enables collaboration during the innovation process (Ballon et al., 2007; Almirall and Wareham, 2008; Leminen et al., 2012). This is motivated by the notion that involving various stakeholders is a way for companies to keep up with the fast-paced digital innovation landscape. Many living labs strive to be 'open innovation platforms', providing a trusted environment for interactions between all relevant stakeholders for a particular set of innovations. This constellation can include e.g. a cooperation between living lab practitioners and businesses, social profit organisations or more loosely structured communities, an innovation consortium, a business cluster, a public-private partnership, or a university involving its professors and students.

Living lab *approaches* borrow from a.o. action research and user-centric design, and apply various methods and tools from these traditions to achieve some of the goals stated above. They routinely involve the active participation of living lab practitioners in the innovation process that they study and support. The practitioners are involved not just in a reflective capacity but also in activities such as problem-setting and problem-solving (Pierson and Lievens, 2005; Schaffers et al., 2008; Kiemen and Ballon, 2012; Coenen et al., 2015). Typically, living labs follow an iterative cycle of activities including requirement elicitation, co-design, prototyping, testing and monitoring, and commercialisation. The iterative approach is reinforced by the interactive nature of living labs, the learning effects that arise during the living lab activities and the complexity and uncontrollable dynamics of real-life environments (Katzy et al., 2012; Tang and Hämäläinen, 2014; Leminen et al., 2015; Leminen and Westerlund, 2017).

The design focus of living lab approaches stems from traditions that emphasise the benefits of user involvement in the design process including user-centred design, participatory design and interaction design (Ståhlbröst, 2008). It has been said that in living labs, von Hippel's (1988) concept of (lead) user-driven design and Silverstone's (1993) insights into the appropriation and domestication of technologies into users' daily lives are coupled dynamically through experimentation (Frissen and Van Lieshout, 2006). Many living labs have therefore embraced principles of co-design, co-creation and co-development of products and services, not simply in order to tap into various stakeholders' creativity and create more value, but also as a means of empowering users and 'democratising innovation' (Björgvinsson et al., 2010; Romero and Molina, 2011).

At the 'meso-level' of living lab innovation *projects*, ideally a 'macro-level' open innovation environment is coupled with 'micro-level' user involvement approaches (Schuurman, 2015). However, there is often a disconnect, both in theory and practice, between those identifying living labs primarily as *environments* (emphasising e.g. the real-life aspect or a multi-stakeholder setting) versus as *approaches* (emphasising e.g. co-creation activities or user-centric methods). Also, the practice-driven, pragmatic and multi-disciplinary character of most living labs tends to reinforce the theoretical and methodological inconsistencies across the various initiatives.

As a result, while most living labs share a similar vision, several studies have demonstrated that there is strong heterogeneity in terms of the interpretation and implementation of that vision, to the point that it is hard to compare actual experiences. In terms of organisational set-up, living labs encompass a range of (semi-)permanent as well as temporary projects associated with academic institutes, large technology vendors, municipalities or non-profits, innovation consultants, design or marketing companies, industry clusters, and so on. The number of users involved in living lab testing and experimentation ranges from a handful (e.g. in some homecare living labs that necessitate the installation of complex or costly equipment in users' homes) to several thousands (e.g. in the case of large online or offline communities of practice involved in living lab trials). A number of living labs have turned predominantly to information retrieval and crowdsourcing online, using social media as a living lab environment. Others have extended their scope to treat entire (parts of) 'smart cities' as living labs, making use of mobile, location-based social media and sensor network data. Many questions related to the nature and characteristics of living labs, their methods and effectiveness, their application domains and new avenues for research, therefore remain unanswered (Følstad, 2008; Azzopardi and Balog, 2011; Schaffers et al., 2011; Ballon, 2015; Ballon and Schuurman, 2015).

Moreover, while a large community of practice exists, and living labs are increasingly recognised as part of the innovation 'instrumentarium', this heterogeneity and lack of consistency in terms of definition, objectives, scope, setup and *modus operandi*, place

a burden on the credibility of the living lab 'movement', and jeopardise its further development (Leminen et al., 2012; Leminen and Westerlund, 2016; Nyström et al., 2014). Moreover, it has also been argued that the living lab community is increasingly facing a series of challenges in terms of whether it is able to deliver on its promises related to the value of its user-driven approach, open business collaboration, and so on (Dutilleul et al., 2010; Schuurman, 2015).

It can be argued that the main way to tackle this issue, as well as to ensure a stronger focus among the diverse initiatives, is to start evaluating thoroughly the effectiveness and impact of specific living lab experiences. However, while most scholars and practitioners appear to agree on this, no systematic impact studies of living labs exist up until this day. One reason for this is to be found in the historical roots of living labs, i.e. the rather idealistic tradition of social experiments and cooperative design on the one hand, and a range of 'techno-optimistic' or 'technology-push' initiatives on the other. Neither tradition has typically been concerned with systematically measuring impacts.

Another reason is that, while their heterogeneity makes it often impossible to compare projects across different living lab organisations, the number of living lab projects carried out by a single organisation are usually relatively small. A relatively large proportion of living lab initiatives are even single-project endeavours (Ballon and Schuurman, 2015; Schuurman, 2015). For these reasons, this first step towards a systematic impact evaluation of multiple living lab projects intends to inform and move forward both the scholarly debate on living labs as well as the actual living lab practice and setups.

3. Impact evaluation and living labs

3.1. Concepts and issues

In order to conduct an impact evaluation of living lab projects, a number of concepts and issues need to be taken into account. Impact assessment or evaluation are essentially about identifying effects of certain actions or decisions; in other words, about identifying and evaluating a certain change caused by a specific intervention. The terms impact assessment and impact evaluation tend to overlap, but may carry different connotations. While impact assessment is often applied to e.g. *ex ante* or mid-term assessments, impact evaluation sometimes has the connotation of being carried out primarily *ex post*. In some traditions, evaluation is linked to more rigourous causation or attribution models than assessment. Also, the notion of counterfactual analysis (i.e. being able to compare with the likely outcomes in the absence of intervention) is often linked to the concept of impact evaluation (Khandker et al., 2009; Streatfield and Markless, 2009).

Even if frequently used in areas such as financial aid and development programmes, health care, R&D or other project proposal reviews, and specific fields of policy analysis, both impact assessment and evaluation are complex exercises, fraught with methodological and epistemological issues (Renda, 2006). A number of these are especially relevant to the impact evaluation of living labs.

The first issue when conducting an impact evaluation of living labs relates to causation, i.e. how to establish a causal link between actions or decisions and effects. It is the nature of impact evaluation that this is to an extent problematic and imperfect, since impact denotes a rather broad range of potential effects, both direct and indirect. In cases an evident, immediate link between efforts and outcomes can be established, other techniques such as performance measurement can be used. Therefore, concepts such as causal proximity are sometimes put forward to denote the continuum from weaker to stronger causality (Mohr, 1995). In the case of living labs, it can be assumed that the causal link between various iterations of multi-stakeholder inputs (including those of living lab practitioners, living lab test users, clients and professional innovators) and functional outputs, business outcomes and socio-economic impacts will be difficult to establish in a clear and direct way.

Closely linked to the question of causation is counterfactual analysis. This is often realised by means of a control group. Yet, various sorts of selection bias can occur and unobserved factors can render the use of a control group less suitable. In those cases, 'deadweight', i.e. change that would have happened regardless of the intervention, is assessed e.g. by comparing the behaviour of those being assessed before and after the intervention (OECD, 2014). Another approximation of causality in impact evaluation is the establishment of a causality chain: a hypothesis about a chain of effects that can be checked against empirical data. Linked to this, the proxy of goal achievement is also often used in cases where causality cannot be easily established (Leeuw and Vaessen, 2009).

In most if not all living lab cases, there is the additional problem of multiple causality, i.e. the confluence of several causes, which makes it hard to distinguish whether an individual intervention led to an the observed outcome. This is sometimes compounded by the issue of circular causality or endogeneity, i.e. when there is feedback from the outcome on the cause. This happens for instance when trying to assess the impact of innovation policy on productivity or GDP growth. The issue of multiple causality also aggravates as time passes after the intervention has taken place. This is one of the reasons why, even if it is considered in many domains that impact evaluations should ideally be carried out months or even years after the intervention has finished, in practice such evaluations tend to remain rather scarce (OECD, 2014; Vuolle et al., 2014; Cekan, 2015).

The debate about attribution versus contribution is crucial in this respect, *a fortiori* in the case of living labs. For part of the impact evaluation community, no impact evaluation is valid without attribution, even if, as in the case of multiple causality, that does not need to be sole attribution. Yet, in many instances, attribution is hardly possible because of the reasons outlined above. Therefore, others have started to focus on contribution analysis as an equally valid approach. The goal of such an approach is confirming that an intervention is a contributary cause, without necessarily being able to attribute precisely to which extent (White, 2010; Mayne, 2012).

The second main issue related to impact evaluation has to do with scope. This is linked to the question of what outcomes are deemed relevant for the evaluation. For instance, are only outcomes considered related to objectives that have been formulated explicitly at the time of intervention, or is another, possibly broader scope taken? And even when only pre-defined objectives are

chosen, to which extent have they been operationalised into concrete targets? Also, it matters greatly whether evidence is sought for outcomes which can be fairly easily measured or approximated, or not. This is true for both economic outcomes (e.g. turnover, productivity gains or private money invested in R&D versus a firm's innovative capabilities, intellectual capital or structural changes in the economy) and societal outcomes (e.g. mortality or voter turnout versus social cohesion or empowerment). Outcomes can also be monitored at different levels, such as the performance of individual firms, but also that of industries or the economy as a whole (Capron and van Pottelsberghe de la Potterie, 1997; OECD, 2014).

Next is the question of how to demarcate and isolate outcomes. Indirect outcomes, such as spillover effects on a broader set of people or organisations than the ones the intervention was originally targeted at are often of interest but add to the complexity of the analysis. For instance, in the case of the evaluation of granting R&D subsidies to a specific firm, it is important but quite complex to estimate not just the effects of those subsidies on the private R&D spending or economic performance of the firm in question, but e.g. also on complementary investments by others or on the economic performance of complementary firms. Other sorts of spillovers, such as the effects on the target group from interventions that are not under scrutiny, or effects of the intervention on the control group also frequently occur and, if not accounted for, negatively affect the validity of the analysis. In the same example of R&D subsidies to a specific firm, this may happen because of competitive investments by non-subsidised firms in the control group. Finally, it is also important to account not just for positive but also for negative impacts. Again using the same example, this happens when e.g. public R&D subsidies lead to the crowding out of private R&D investment (Klette et al., 2000; Wallsten, 2000; Bozeman and Melkers, 2013; Bronzini and Piselli, 2016).

In sum, a clear trade-off is present in terms of breadth versus preciseness; and consequently, choices need to be made, also in the case of the evaluation of living labs. It is important to note here that there is no single optimal answer to this question, so these choices will be to an extent arbitrary.

All of this is related to the third issue that dominates debates on impact assessment and evaluation, i.e. that of the appropriate methods. Much has been written on the benefits and drawbacks of qualitative and quantitative methods, the applicability of experimental or quasi-experimental methods, the use of participatory methods of evaluation, the appropriateness of specific methods for ex ante versus ex post assessments or for attribution versus contribution studies, the dependent or independent relation of evaluators vis-à-vis the evaluated phenomenon and so on (see e.g., Cook and Reichardt, 1979; Mayoux and Chambers, 2005; Garbarino and Holland, 2009; Khandker et al., 2009; White, 2010; Liket et al., 2014; Mueller and Gaus, 2017).

While it is beyond the scope of this paper to offer any in-depth discussion of these matters, what can be argued is that a broad or exploratory scope of impact evaluation tends to favour qualitative methods, as does a relatively small scale of interventions, while quantitative methods tend to be preferred in the opposite circumstances. Also, that no single method shields researchers and practitioners from difficulties in modelling, gathering information, sensitivity to arbitrary choices or from a number of other basic issues. For instance, the serious methodological drawbacks related to self-reporting and self-assessment in participatory approaches are mirrored by equally serious limitations of more rigourous quantitative methods related to e.g. understanding *why* an intervention had a certain effect. Therefore, the range of qualitative and quantitative assessment tools should be seen as complementary and interrelated. In many cases, and especially in complex settings such as the impact evaluation of living labs, the optimal configuration will be a mixed-methods approach with qualitative and quantitative inputs and methods combined, related to the goals of the specific evaluation (Greene et al., 1989; Capron and van Pottelsberghe de la Potterie, 1997; Rao and Woolcock, 2003; Berriet-Solliec et al., 2014; Copestake, 2014; Gertler et al., 2016).

Still, it needs to be stressed that impact evaluation is in no way a clear-cut exercise, and that several methods and approaches, however optimal in theory, are in practice only rarely or poorly used. A review by the International Initiative for Impact Evaluation (3ie) of studies on the impact of development aid, for instance, showed that not one of 339 evaluation studies reviewed could be classified as a rigourous impact evaluation (White, 2010).

3.2. The impact of living labs

In previous years, a handful of scholars have started to explore the notion of impact assessment and living labs. These attempts go against the general tendency of living lab papers to describe single living lab projects or make comparisons between different living lab organisations, actors or activities in a descriptive manner. Although these papers are valuable in describing the current 'as is' in terms of living lab practice, they fail to pinpoint the impact or added value living labs generate compared to other approaches.

Ståhlbröst (2012) emphasises the need for living labs to demonstrate their value to stakeholders, but at the same time the difficulty of assessing their impact, as their activity is hard to define, and thus hard to translate into generalisable models. Also, they are mostly employed in the area of service innovation, which makes measurement of outcomes cumbersome. Based on a review of living lab projects, she puts forward five principles which should guide the assessment of their impact: (1) Value: whether living labs are able to create value not just for all partners involved in the project but also for eventual customers and users; (2) Sustainability: the question of whether living labs take responsibility for the environmental, social and economic effects they create; (3) Influence: the degree to which influence of users on the innovation and development processes shaping society, is stimulated and enacted; (4) Realism: the degree to which results are generated that are valid for real markets by orchestrating realistic use situations and understanding users' behaviour, and (5) Openness: whether the adequate level of openness is employed in terms of ideas, activities and results to be able to cooperate and share in a multi- stakeholder milieu. Ståhlbröst then proceeds to give a description of how these principles were enacted in a LL project. However, no analysis or guidance is given on how these principles should be operationalised or assessed.

In other papers on living lab practices, reported outcomes are usually descriptions and analyses of project results (see e.g.

Brankaert et al., 2015; Salminen et al., 2015; Pedell et al., 2017), even though some have started to incorporate basic self-reporting of living lab participants. However, these papers fail to deliver conclusions that go beyond the projects described or analysed.

As part of a European project deliverable report, Schaffers et al. (2012) provide an assessment of how a living lab test project allowing SMEs to test their product or service in another country affected their subsequent international business activities. In total, 11 participating SMEs were surveyed as to their revenues, number of employees, year-on-year revenue growth and international revenues. The delta was reported between the pre-project, mid-term, and near-end situation of the 30-month project. Mostly positive effects were identified in terms of international business activities, with a number of SMEs achieving international turnover for the first time in their existence, and various firms increasing their reliance on international revenues. Qualitative questions were added to verify the importance of the living lab activity for the achieved growth, e.g. by comparing the intentions of the participating SMEs to use living labs as a means for internationalisation in the future, to other instruments. One important caveat here is obviously that this analysis was entirely reliant on self-reporting by the firms as part of a project deliverable to justify subsidies received. The project did not attempt an independent verification or more sophisticated modelling or hypothesising on impact. Also, the assessment did not cover the period after the end of the project. Therefore, while a useful example, this report provides indications of impact rather than proof.

An example of a wholly qualitative self-reporting assessment is given by Ståhlbröst (2013). Based on interviews with five managers of five micro-enterprises that engaged in living lab projects, this paper identifies three main areas where these have provided value for the micro-enterprises. First, managers indicated the value of an 'outside view' provided by the living lab researchers with regards to the innovation in development. Second, the fact that living labs offered the micro-enterprises a more structured innovation approach that facilitated user and other stakeholder feedback using a specific methodological flow, was highlighted. Third, a number of specific insights and contributions that were gathered from users and that improved the innovation itself were mentioned. Managers also indicated that they planned to continue using living labs in the future. Again, this study indicates positive impacts from Living Lab projects, relying on self-reporting, but also in this case statements have been mostly taken at face value, and have not been further specified.

Veeckman et al. (2013) provide a conceptual framework for linking living lab environments, approaches and innovation outcomes to each other. Four living lab organisations are compared related to a number of defining characteristics, in the form of a score on a four-point scale given by two living lab researchers. However, outcomes are only assessed in the form of a limited number of practitioner guidelines. As a final example, Logghe and Schuurman (2017) describe a living lab evaluation done in an action research mode, whereby one researcher took part as a test user in three living lab projects, and reports on the outcomes and experiences from an individual living lab user point of view.

It is safe to conclude with Schuurman et al. (2016) that impact assessment of living labs has until present remained anecdotal. Reviewing the literature up to that point, Schuurman et al. argue that gathering evidence on living lab outcomes should be separated according to how the particular living lab initiative is defined. This can be conceptualised in terms of three complementary levels. Thereby, the organisational level (the 'living lab as environment') can be evaluated according to collaboration and interaction variables that deal with aspects such as knowledge transfer, and the user involvement objectives (the 'living lab as approach') can be assessed according to criteria related to the manner in which end-users and other stakeholders are able to influence innovation processes. The living lab 'meso level', i.e. the actual living lab projects, however, needs to be assessed primarily as to whether these projects generate value for the innovator, i.e. from an economic perspective.

4. Methodological considerations

4.1. The case study

The living lab impact evaluation reported here follows these guidelines. It refers to the living lab projects that have been carried out by a large organisation offering living lab services, mostly from 2012 and up until 2015. For this evaluation, which took place during the summer of 2015, researchers collaborated with an independent evaluator firm, that was selected through a tender procedure. The role of the evaluators was to carry out an independent assessment of the effects of the living labs programme. Researchers from the living lab provider did not have influence on the evaluation design nor on the data gathering or processing, apart from taking part in an important scoping workshop that will be referred to later. While some of the underlying data is confidential in nature, the methodology as well as the aggregated qualitative and quantitative results and estimations presented may serve as a first 'benchmark' against which future impact evaluations of living labs can be compared and further refined.

The organisation being evaluated was a non-profit research institute, with a dedicated living lab unit involving up to 20 project and programme managers, panel managers and application prototypers working on the operational aspects of living labs, and a similar amount of user and business researchers involved in living lab-related research projects, during the timeframe referred to here. The living lab projects executed by this team include a series of large-scale innovation projects in which typically various complementary businesses or non-profit organisations were involved, and using various real-life contexts, including houses of a street block, elderly homes, museum buildings or an entire city. Starting in 2011, a specific service was developed for individual SMEs (including startups) wishing to develop or test an ICT service. A tailored approach was worked out, covering three innovation phases: exploration (from basic vision to ideas and concepts), experimentation (testing the limits of a product of service and its use in the long run) and evaluation (validation of user interest and business model). Typically, SMEs would be required to pay 20–25% of the project cost, with public subsidies covering the remainder.

The following services were part of the living labs offering, and would be combined depending on an assessment of the needs of

the SME involved:

- Co-creation sessions: Brainstorm on the innovative idea or product during a common session with selected test users
- Stakeholder interviews: Individual interviews with business stakeholders concerning the innovative idea or product
- User survey: (Often online) survey among test users concerning the innovative idea or product
- User interviews: Individual interviews with users of the innovative idea or product
- Usability/UX testing: Testing of the user friendliness of the product in a closed lab environment
- Field tests: Test users apply the product in their daily context during a short or longer period of time
- Business model workshops: Workshop to analyse and evaluate the business model of the innovative idea or product
- Application prototyping: The prototyping of test applications or user interfaces to be used in the tests.

As outlined above, it is necessary that, prior to any impact evaluation, and especially in the case of living labs, a number of informed choices are made related to the object of the evaluation, the object of measurement, and the approach to be used. In order to derive useful results, it is important to render these choices explicit.

The first choice revolves around the object of the evaluation. In this evaluation, it was taken that a living lab project is about an innovation in the sense of a new artefact, i.e. a digital application with potentially an accompanying business model and go-to-market strategy. This implies that improvements or digitisation of company-internal processes or organisational modes are not regarded as the primary objective of the living lab projects scrutinised, and thus not evaluated in detail.

Additionally, only projects aimed at the generation, development and testing of a specific service or product idea of an individual small and medium-sized company were targeted for evaluation. Broader, multi-partner living lab projects, fully subsidised research or governmental projects were not evaluated. This was motivated by the aim of reducing multiple causality and increasing the measurability of effects. Also, it aimed to reduce self-report bias, as in the selected projects, SMEs had incurred out-of-pocket costs and spent considerable efforts on an activity that they would not routinely engage in, and thus were assumed to respond rather as critical clients than as partners with a stake in a positive evaluation outcome. Therefore, when SMEs were approached, the research was not positioned as a survey on the proper use of subsidies, nor as an assessment of the SME's innovation performance, but rather as an independent assessment of the added value of the provided living lab services.

Subsequently, a second choice was made, i.e. what to measure. For this step, it was important to look into the initial objectives of the programme and identify both qualitative and quantitative indicators to cover in the evaluation. For the qualitative part, questions were based on the logical effect model (cf. infra). For the quantitative part, and given the issues of previous living lab literature to come up with empirical data, it was opted to focus on tangible impacts of the living lab project on employment, investment, and turnover of the client companies. The selection of projects for evaluation was not based on their perceived success, but only on whether they could be linked to a service/product idea of which the success or failure could subsequently be traced.

Finally, a third set of choices relate to the measurement method. In order to operationalise causation in the case of living labs, a causality chain referring to the effects of living labs needs to be constructed, based on the initial objectives of the programme. Also, while it can be expected that in this case a control group would not deliver a clear basis for comparison, the focus on the introduction of a specific new service or product by single SMEs provides the possibility for a counterfactual analysis, i.e. related to the business of this SME without that service or product. Still, because of multiple causality - the living lab project cannot be assumed to be the only reason for developing or launching the service or product innovation – as well as endogeneity – caused a.o. by the iterative nature and action research-mode of living lab projects -, the evaluation allowed for contribution and not (sole or non-sole) attribution (see further).

All of these choices enabled a qualitative-quantitative approach in which self-reporting by SMEs was used, but whereby its drawbacks could be offset by extensive verification. The choice for a micro-level approach that combined an online survey with interviews with each of the project coordinators of the individual cases, enabled the collection of detailed quantitative information and the validation of the living lab's contribution to this, as well as contextualisation of the qualitative information. This methodology is relatively new in the field, but allowed to mitigate the already mentioned risks of exogenous factors in counterfactual analysis and attribution issues. Similar interview-based approaches are increasingly observed in evaluations of the effects of collaborative research projects (see e.g. Colinet et al., 2014).

Still, rather than to strive for universally comparable evaluation data, the first purpose of the study was to develop a methodology to measure the effects of living lab trajectories. This methodology was then tested with an initial evaluation of the main economic outcomes of the living lab projects, and was intended as a first base measurement.

4.2. Logical effect model for living lab projects

The first step of the impact evaluation was to construct a logical model of the effects of a living lab trajectory. This refers to the causality chain or chain of effects as mentioned above. Since no pre-existing and homogeneous set of operationalised objectives for living labs exists, a typified chain of effects was assembled on the basis of a literature study combined with a workshop in which evaluators, living lab managers and practitioners took part. In a first step, the evaluators developed a logical model based on the available information on the living lab programme's objectives and literature with a broad perspective on objectives, structures, critical success factors of living labs, etc. In a second step, this draft logic model was discussed, complemented, refined and validated in a workshop with practitioners in the specific living lab programme. The logical effect model served as input for the development of the questionnaires for the SMEs and the analysis.

A logic model is defined as a logical and consistent description of the design of the living lab programme and its results and effects. The model that was created consists of three main layers: (1) Inputs: the material and immaterial means used to conduct the living lab activities; (2) Activities (and the associated output): the activities, events or services directly financed by means of the inputs, and (3) Objectives (and the associated effects): the intended (and achieved) results of the activities, i.e. the changes that are effectuated.

Subsequently, in order to define the scope of the evaluation, and to make explicit its limitations, the potential effects are classified according to two dimensions. The first dimension is that of the timeframe in which the effects are expected to occur, i.e. (1) Short-term: *during or directly after* the living lab project (defined as less than one year after completion); (2) Mid-term: effects occuring *after* the project (defined as over one year and under three years after completion), and (3) Long-term: effects occuring *long after* the living lab project (defined as over three years after completion). Since attribution becomes highly problematic for long-term effects because of a.o. the multi-causality issue, the measurement framework was limited to short term and mid-term effects. This distinction in terms of effects is mirrored in terms of the categorisation of objectives, where a distinction was made between living lab project objectives, mid-term operational objectives and longer term strategic objectives.

The second dimension is that of the level at which the effects play out, i.e. (1) Involved companies. It was hypothesised that participation in a living lab project can lead to effects on the operation, organisation, production, sales, or even knowledge building or strategy of a firm. Types of effects that can be partly or fully attributed to participation in a specific living lab project include the development of a good that is more closely attuned to market needs and bringing that good to market or stopping a development after negative results from a living lab trajectory and allocating inputs to more productive use; (2) Consumers or users. A living lab project can also be hypothesised to engender effects for consumers and users that are directly or indirectly implicated in the living lab project. Testing a good in realistic circumstances ideally leads to improved products and services and increased value for them, and (3) Society. It is possible or likely that there are also effects on groups in society not implicated in the living lab project. However, societal value, or indeed negative societal effects, are often only measurable after a more extended period, and can seldom be attributed to specific projects. An important choice in this case was to limit the impact evaluation to the effects on the first level. This is in line with the argumentation of Schuurman et al. (2016) related to the 'meso level' of living lab projects, with the primary objectives of the living lab provider, and was also done with a view on measurability. Still, it is an important limitation of the present evaluation, and not necessarily applicable to all other living lab trajectories, e.g. those aimed at societal innovaton.

The above is not to imply that no relations exist between the various dimensions and levels of objectives and effects. While living lab project objectives are in principle specific to an individual project, and to be realised on the short term, these objectives are often the reflection of a goal at the operational level (such as new market entry or the creation of a spin-off), or even at strategic level. In the longer term, a project ideally contributes to the realisation of more strategic objectives. Also, there is no one-on-one relationship between the various levels of objectives and effects. The project objectives linked to one project can contribute to one or more operational objectives, and a combination of various project and operational objectives typically lead to the realisation of a strategic objective. Ideally, all projects ought to aim for at least one strategic objective in the long run.

The living lab project objectives, and potential short-term effects, identified through the literature study and the workshop, comprises 18 potential effects, ranging from testing the product-market fit to attracting private financing or increasing the internal knowledge and competence level of the firm. Furthermore, 7 operational objectives, and potential mid-term effects have been identified, ranging from new market entry to the creation of a spin-off company. The resulting logical framework used for the impact evaluation - as the basis for the questionnaire directed at the sample of participating companies -, is depicted below (Table 1).

4.3. Methodological approach

The second step is to work out the methodological approach and bring it in line with the particulars of living labs. A succinct overview of the methods used is given in Table 2. As the first purpose of the study was to develop a methodology to measure the effects of living lab trajectories, the methodological risks associated with each analytical step are explicitly highlighted, as well as the way in which the choice or combination of methods aims to mitigate them.

With the characteristics of living labs in mind, a special focus of this approach must be to ensure the gathering of a dataset on market impact that can be interpreted uniformly, as well as to take into account a number of qualitative effects sought after by living labs, such as the alignment of product characteristics to user needs, the limitation of risks associated with innovation, networking and attracting investors (based on the logic model).

Therefore, it was deemed vital to combine quantitative and qualitative questions, and to accompany the online evaluation survey with preliminary and subsequent calls with company respondents. The process is presented in more detail per evaluation step in Table 2, along with a discussion of how the risks in each evaluation step are mitigated by the approach. This approach again stresses the importance of thorough preparation by evaluators, and the need to address the issue of uniform understanding of living lab objectives and activities with all stakeholders involved. In this case, the risk of induced bias is outweighed by the risk of heterogeneity and imprecision. Naturally, this approach can be adjusted as the maturity of living lab service offerings progresses.

The questionnaire was developed based on the logical effect model constructed earlier. Each of the potential effects was included in the qualitative part of the questionnaire, and respondents were asked about which intended outcomes were important to take part, as well as the ones that were eventually achieved. The quantitative part was concerned with the concrete effect on investments, employment and revenues. The final questionnaire was constructed in four parts: (1) Use, usefulness and value of the living lab project; (2) Initial objectives and achieved effects; (3) Effects on investments, revenues and employment as a consequence of the living lab project results, divided into three time dimensions: realised at end of project, realised between the end of the project and

Table 1
Logical Effect Model Living Labs.

1. Inputs	Mobilising assets (financial & human), mainly through private funding, SME innovation vouchers, funding for feasibility studies, national and international R&D funding Follow-up investments
2. Activities	Living Lab research, enabling the development of innovative solutions involving multiple stakeholders to achieve a stronger product In application areas including ICT, digital media, e-health, smart cities, smart energy, manufacturing
3. Objectives/4. outputs	
a. Living Lab Project Objectives/Short-Term Effects (during or directly after LL project)	Increasing knowledge and competence level Coordinated elaboration of an innovation idea Insights into own USPs/positioning in the market Adjustment of R&D or product roadmap Testing product-market fit Better understanding of the market Go/no go for firm investment Matching new business with existing strategy Creating a go-to-market strategy Identification of lead users ("ambassadors") Development of a minimum viable product Accelerating the innovation process Involving user and other external viewpoints in a particular innovation process Attracting private financing Attracting new private financing for RDI More efficient product or process development Reducing risks of product or process development Improving a product
b. Living Lab Operational Objectives / Mid-Term Effects (1–3 years after LL project)	New market entry Expanding existing market(s) Increasing revenues New job creation Ensuring the continuity of the company Creation of spin-offs or spin-outs Increased credibility and bargaining power
c. Living Lab Strategic Objectives/Long-Term Effects (> 3 years after LL project)	Increasing competitive strength …

the moment of the survey, and expected in the two years after the survey; (4) Research, Development & Innovation (RDI) activities of the firm.

The total population for this evaluation were all living lab projects effectuated by the living lab provider that complied with the following selection criteria:

- Only full projects with a clear living lab approach (i.e. no projects in which living lab activities played a minor part or experimental set-ups with 'friendly users')
- Projects that had ended by the start of the impact evaluation, without any filter as to their closing date
- Projects with clear single project instigator (i.e. no long term programmes with multiple partners)
- Only projects with Flemish companies as main participant

These criteria were instituted because of uniformity reasons and to limit attribution/contribution issues, but also to ensure a sufficient sample of respondents. The major implication was that all living lab projects evaluated were linked to a particular company and/or ICT product or service. This finally led to the selection, mainly based on the extent to which the living lab approach was applied fully, of 20 living lab projects for evaluation and to contacting the 20 involved companies. The perceived success or results of the projects by the living lab practitioners was not a criterion for selection. In the end, evaluators were able to gather all data on a sample of 14 living lab projects. In this way, the sample represents around one third of the total project population.

As project participants were small and medium sized companies, it was relatively straightforward to select respondents with direct knowledge about the living lab project, as well as easy access to data. Often, respondents occupied leading positions related to innovation or management in the company. The risk of socially desirable responding was reduced by strict anonymity of respondents and confidentiality of individual results, as well as the fact that the evaluation was not positioned as a justification of any innovation funding received, but as an evaluation of the living lab services offered and which their companies had co-funded.

The combination of the online survey and the extensive validation interviews was mainly used to systematically assess correctness and uniformity of the results. This proved crucial to (1) avoid double counting between e.g. investment and employment; (2) obtain a consistent interpretation of employment, i.e. how to define 'new jobs' and 'maintained jobs', how to account for employees working on the living lab project, etc.; (3) translate full time equivalents (fte's) into actual person years in order to be able to estimate total capacity; and (4) validate additionality and attribution, i.e. whether the perceived impact was effectively the result of participation in

Table 2
Overview of used methods.

Evaluation Step	Risk	Method	Process	Manner in which the method and process addresses the risk
Development of evaluation framework	Lack of operationalised objectives	Desk research & practitioner workshop - Mapping of success factors and effects of living lab trajectories - Development of a logic model based on the objectives of the living lab programme and the identified success factors - Development of a causality chain identifying the expected effects of the living lab trajectories based on the logic model - Basis for questionnaire and analysis	1. Desk research of existing literature and information on the specific living lab programme's context, set-up and objectives 2. Evaluators prepare a draft logic model 3. The draft logic model is discussed in a workshop with practitioners to complement and refine, tailored to the specific programme, and validate the logic model as basis for the data collection process (questionnaire) and analysis	Clear, specific (tailor-made) evaluation framework that is validated by the practitioners of the living lab programme as relevant and complete. Validated basis for data collection and analysis. Guarantee that the results of the study will be able to link the effects to the initial objectives of the living labs.
Data collection	No systematic monitoring of effects in existence No company specific data available on effects that cannot be measured by public corporate data Low response to questionnaires by firms Questionnaires leading to socially desirable responding Complexity of topic leading to inconsistent interpretation of received answers	Explorative interviews with companies that participated in LL project - Extension of the mapping of success factors and effects of living lab trajectories - Testing of the questionnaire	4. 3 explorative interviews to complete the questionnaire and test the data companies are able and willing to share with evaluators	'Pilot' measurement to assess feasibility
		Online survey - Impact measurement of the living lab projects	5. Preliminary call to announce and explain the objectives of the evaluation and increase willingness to participate 6. Online survey with possibility of easy downloading the survey by participants: - Increase ease of use - Preparation and retrieving data by participants while answering is possible (multiple sessions and adjustments to answers by participant possible) - Link can be shared with other colleagues within firm - Efficient processing	This approach increases the willingness to participate and optimises the conditions for data collection in an extremely user-friendly tool.
		Follow-up/validation interviews - Supplementing and validating the online survey responses	7. Follow-up call: Going through answers of questionnaire, gathering of contextual information to ensure correct and uniform interpretation by evaluators related to data, attribution etc. 8. E-mail validation:Subsequent e-mail validation by participant of every adjustment made to answers or data to get final confirmation by firm	Full validation of the consistent interpretation and attribution of the effects to the living lab trajectory.
Analysis		Analysis - Analysis of the qualitative and quantitative data gathered	9. Qualitative analysis of the expected and realised effects and of the value added of the living lab trajectories for the SMEs. 10. Quantitative analysis of the economic effects on employment, investments and turnover.	The validated and consistent dataset allows uniform interpretation and processing. Attribution issues have been addressed and are included in the interpretation, in order to accurately reflect the economic effects directly linked to participation in the living lab projects studied

the living lab project, or whether other projects or contextual factors were the main drivers. Also, the respondents were systematically asked how they arrived at their calculations and which sources they used for this (e.g. profit & loss statements, project administration, etc.).

Finally, in terms of the analysis, the principle of conservatism was used. In case of doubts or of insufficient additionality, each time conservative estimates were used. In some instances, for example, it is difficult to estimate the number of fte's working on a project or product, independent of other activities within the firm. Therefore, in such cases, the number was set to zero or respondents were asked for a conservative estimate. The reported figures for e.g. jobs on the project and expected jobs may therefore be considered as the lower boundary.

5. Results

5.1. Characteristics of sample projects and firms

All 14 living lab projects that were scrutinised contained user research, in the form of user interviews (12/14), user surveys (12/14), field trials with users (11/14), co-creation sessions or user experience testing (6/14). Also, prototyping activities (9/14), and business modelling support (7/14) were coupled to the user research. In 5 out of the 14 living lab projects, user research, prototyping and business modelling support were combined. Largely in line with the overall population, 3/14 companies were medium-sized, 3/14 were small or micro-enterprises, and 8/14 were startups. 5/14 companies were in existence for over 2 years.

The total budget of the 14 sample projects amounted to 373 k€ (i.e. 46% the total population budget of 814 k€), of which 304 k€ came from public subsidies in some form (innovation vouchers, R&D funding programmes, etc.). This means that, on average, project size for the sample was 27 k€, of which around 80% was financed by means of public innovation support. One larger project in the sample raised the average project budget, which was typically around 20 k€ for the total population, of which 14 k€ publicly funded. Public support was deemed important by all participants, and in particular by start-ups, since they are confronted by high project costs relative to their total capital as well as high risks since the product or idea is often the basis for the entire activity of the start-up.

All innovations targeted in the projects concerned ICT products and services, including for instance a mobile gaming platform, a reporting application, a cloud solution for specific payment services and an online commerce platform, but the companies involved were not necessarily ICT companies themselves. They represented both business-to-business and business-to-consumer firms, in line with total population. Most participating companies can be labelled innovation driven enterprises or IDEs (Aulet and Murray, 2013), as they are relatively RDI-intensive, with 7/14 having a specific yearly RDI budget, 5/14 having a separate RDI unit, and 8/14 regularly participating in RDI projects, in half of these cases more than one at the same time.

In general, respondents indicated that effects are seldom unequivocally attributable to the living lab project. Often, other factors played an equally important role in the overall process of idea to product in the market. While respondents could estimate the total effect, they were not able to separate the share to be attributed to the living lab trajectory vis-à-vis R&D projects, separate in-house initiatives or follow-up projects. It is therefore important to interpret the findings in the right context: they represent the total effect of the innovation, of which part is with certainty attributable to the living lab trajectory. In several cases, the living lab project was deemed the crucial element in the total effect. For these reasons, findings must be interpreted in terms of the *contribution* of living lab projects to a total effect. It can be expected that, due to the nature of living labs, subsequent evaluations will come to a similar conclusion.

Also, it needs to be repeated that all indicators and results are based on a sample of maximum 14 observations. Notwithstanding the intensive data collection and validation process, this limited number of observations is an important factor in the interpretation of the findings, especially when there is considerable variation in the data. All validated and consistent data was included in the analysis, but the overall implications need to be formulated with the necessary caution.

5.2. Qualitative analysis: Objectives and value of a living lab project

The evaluation shows that the primary objectives for companies to take part in a living lab project relate to incorporating the external viewpoints of users and other stakeholders into their innovation process, improving the product and testing the product-market fit. In second instance, achieving a better understanding of the market and reducing the risks associated with the innovation process are also put forward.

The same objectives were mostly reported as realised, with a total realisation rate of between 79% and 93% for the top 5 objectives, often already during the living lab project.. Next to these, raising the knowledge and competence level, and matching new business lines with the existing strategy/portfolio are prominent among the realised objectives. Two users specified that the results helped to persuade both internal and external stakeholders to continue the development and/or financing.

Choosing to enter into a living lab project has thus, besides the primary rationale of matching the idea or product better to users and markets, also an effect on knowledge transfer and internal coordination within enterprises. The most unexpected effect is new job creation within the company, which was hardly mentioned as an initial goal, but was in many cases realised.

In 21% of cases, the results of living lab project were used to completely discontinue the product idea (for reasons of relevance or feasibility in the market) or to reboot in the form of a completely different product idea. In 57% of cases, the living lab results were used to adapt the product or idea before launch. In 22% of the cases, the results had been used to launch the product in the market. One aspect is the gain in terms of cost-effectiveness when a product development line is stopped based on negative outcomes of the living lab trajectory. Instead of investing more budget to develop the product or idea to a more mature stage, the living lab allowed to

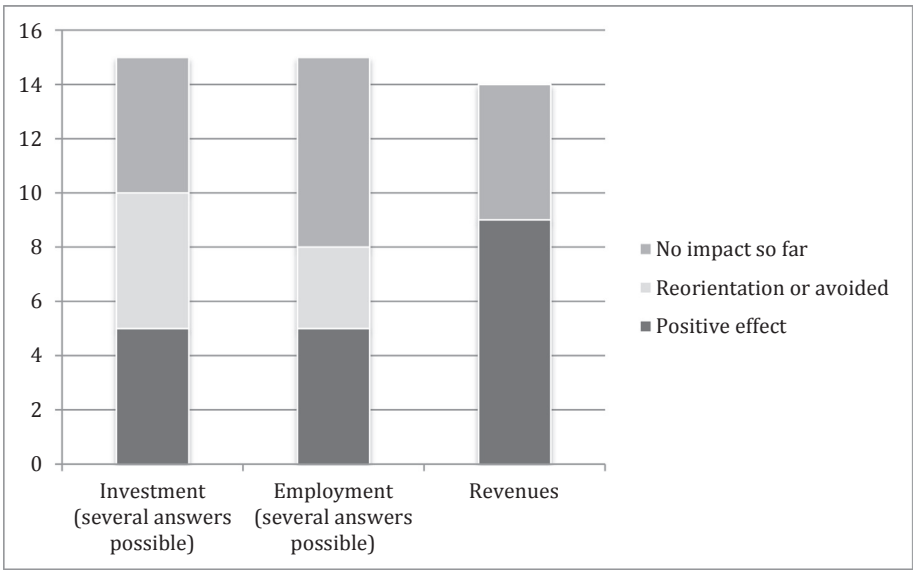

Fig. 1. Overview of effects.

identify already in an early stage that the budget was better reallocated to a more promising product line. In one case, the user immediately reallocated and started a new living lab trajectory for a new idea.

In line with earlier ratings of the living lab provider's service on a government website listing different innovation services providers, 93% of the participants found the living lab projects to be useful or very useful. According to respondents, this was mainly because they allow to take on board information about users and markets early on in the innovation process, or because they allow to reorient investment to more efficient use. The latter motivation explains why respondents whose product or idea was aborted, were also as a rule satisfied or highly satisfied with the living lab trajectory. In a more limited number of cases, acceleration of the development or marketisation of products was mentioned as the strongest point, as well as the provision of evidence for follow-up projects or financing, or the specific expertise of the living lab practitioners. This last aspect may be a relevant factor in terms of generalisability of the results, given the heterogeneity of living lab initiatives worldwide.

5.3. Economic effects of living lab projects

As mentioned above, three types of economic effects were distinguished, i.e. investment, employment, and revenues. These three types have been interpreted as additional to each other, meaning for instance that the investment figures do not contain personnel cost. Therefore, reported effects can be added to each other to estimate the total impact to which living lab projects have contributed: at the input side to investment and employment, and at the output side to revenues.

Both at the input and the output side, substantial effects were established, but the largest share of these were expected within the following two years by the respondents, instead of already realised. This is understandable given the often short timeframe between the closure of the project and the implementation of the evaluation, and because of the experimental phase of development to which most living lab projects in the sample belong. For instance, at the time of the evaluation, many products had not reached the market yet, but hiring additional employees was foreseen for their further development (Fig. 1).

At the input side, significant effects are present. Compared to a total volume of 373 k€ in terms of living lab project cost, of which 304 k€ from public support programmes, the total investment impact is substantial, and is a.o. achieved because of outsourcing. This outsourcing represents a real economic effect at the side of the suppliers of the participating firm. Of that investment, 453 k€ was already realised at the time of the evaluation, with an additional investment of 3.4 mio€ foreseen within the next two years. On average, this amounted to 272 k€ of total investment per company, of which 32 k€ realised at the time of the evaluation. In other words, for 1 public euro invested in the living lab projects, 1.5 euro was realised in follow-up private investment, with an additional 11 euro foreseen. However, it needs to be remembered that these investments are not entirely attributable to the living lab projects, so this cannot be generalised in terms of a leverage effect (Table 3).

In terms of employment, a total capacity of 37.6 person years was deployed (corresponding with 40.1 fte of which 26 fte new employment), with an additional 165.2 person years foreseen for the following two years. In total, at the time of the survey 8.7 euros was realised for every euro invested by public support agencies in all living lab projects in the sample (Table 4).

In addition, there is also a clear reorientation effect of inputs, i.e. 85 k€ in investment and 6 person years that have been put to more efficient use or avoided.

Regarding revenues, again substantial output effects are measurable (with the same caveats as before). A total of 2.23 mio€ in

Table 3
Total and average effect on investment (in €).

	n	Realised at end of project	Realised between project and survey	Foreseen in following two years	Total realised investment	Total realised + foreseen investment
Total absolute figures	14	201.000,0	252.250,0	3.355.000,0	453.250,0	3.808.250,0
Average per company with positive effect	5	40.200,0	50.450,0	671.000,0	90.650,0	761.650,0
Average per company	14	14.357,1	18.017,9	239.642,9	32.375,0	272.017,9

Table 4
Total and average effect on employment.

		n	Realised until end of project	Realised between project and survey	Foreseen in following two years	Total realised employment	Total realised + foreseen employment
Total absolute figures	fte	14	17,1	40,1	89,5		
	fte new	14	5,0	26,0	51,, 5		
	py	14	15,1	22,4	165,2	37,6	202,8
	py €	14	1.058.400,0	1.570.100,0	11.564.000,0	2.628.500,0	14.192.500,0
Average per company with positive effect	fte	5	2,8	8,0	15,7		
	fte new	5	1,0	5,2	8,5		
	py	5	2,5	4,5	29,6	7,0	36,6
	py €	5	177.380,0	314.020,0	2.069.200,0	491.400,0	2.560.600,0
Average per company	fte	14	1,2	2,9	6,4		
	fte new	14	0,4	1,9	3,7		
	py	14	1,1	1,6	11,8	2,7	14,5
	py €	14	75.600,0	112.150,0	826.000,0	187.750,0	1.013.750,0

revenues from the products developed or improved during the living lab projects was realised at the moment of survey, with 11.2 mio € foreseen additionally in the following two years. Also, companies that did not realise any revenue effect at the time of survey, on average expect 80 k€ in the following two years. In total, 6€ of revenues were realised for every 1€ of invoiced living lab budget, with an additional 30€ expected in the following two years (Table 5).

Finally, the relatively large variation in effects is explained by the difference in scale of projects, with the largest project accounting for five times the budget of an average living lab project, strong differences in the rate of success of marketised products, and differences in speed of going to market after the end of the living lab trajectory.

6. Conclusions

The feasibility and effectiveness of user-centric approaches for digital innovation has been a matter of intense debate for several decades. Living labs constitute a prominent example of such an approach. However, because of their complex, multi-faceted nature, most studies have focussed primarily on describing and analysing the set-up of living lab projects, without proper attention to an evaluation of their impacts..

To this end, we reviewed the literature on living labs as well as on impact assessment in order to propose a set of guidelines and conduct the first systematic impact evaluation of a set of living lab projects. Apart from the inherent limitations of such evaluations as already reported, this study is limited in terms of the amount and scope of projects reviewed. Also, it is limited by the fact that living lab projects were scrutinised 'in isolation', while living lab trajectories often form part of a wider innovation process, with many inputs and several iterative feedback loops. Finally, it remains an open question whether the positive results reported could have been achieved in similar form by non-living lab innovation projects.

Still, the impact evaluation reported here provides strong indications that living lab projects can have an important added value for participating companies. The three most reported and most appreciated uses of a living lab trajectory by companies are incorporating the external viewpoints of users and other stakeholders into innovation processes, improving new offerings and testing

Table 5
Total and average effect on revenues.

	n	Realised until end of project	Realised between project and survey	Foreseen in following two years	Total realised revenue	Total realised + foreseen revenue
Total absolute figures	13*	2.000,0	2.231.500,0	11.230.000,0	2.233.500,0	13.463.500,0
Average per company with positive effect	8*	333,3	278.937,5	1.353.750,0	279.187,5	1.632.937,5
Average per company	13*	153,8	171.653,8	863.846,2	171.807,7	1.035.653,8

*For 1 observation, no value for revenue was counted, since the effect could not be estimated with sufficient precision.

the product-market fit.

This in turn can be expected to contribute to significant positive economic effects in terms of investments, employment and turnover. For 1 public euro invested in the living lab projects that were evaluated, 1.5€ was realised in follow-up private investment, with an additional 11€ foreseen. Also, at the time of the survey 8.7€ in employment had been realised for every euro invested by public support agencies in all living lab projects in the sample. Finally, and perhaps most importantly, 6€ of revenues were realised for every 1€ of invoiced living lab budget, with an additional 30€ expected in the following two years.

Despite the heterogeneity and necessarily 'unstandardised' nature of living lab approaches, the evaluation thus yielded a number of measurable results, which can be used as a benchmark for future, similar evaluations, and can serve as a first step towards the evaluation of more complex projects. It illustrates that impact assessment, even of 'fuzzy' innovation tools, is possible, under the conditions that (1) a number of explicit scoping choices are made, (2) a degree of uniformity is achieved through working definitions and the construction of a logical effect model, (3) self-report shortcomings are countered as much as possible by extensive validation and (4) the principle of conservatism is used, i.e. in terms of contribution versus attribution, and for the estimates themselves.

Based on these findings, it can be recommended to practitioners that a systematic monitoring of effects of living lab projects should be done at two instances, i.e. at the end of the project, as well as (approximately) two years afterwards. An evaluation at the close of a living lab project allows an understanding of the immediate appreciation and added value of the living lab trajectory, a.o. by persons that have been directly involved in the test. An additional evaluation round two years afterwards runs the risk that employees and organisational entities have changed, but allows to focus on longer-term effects which can be still traced in the company records.

It is also important that the respondents represent the companies that have effectively taken part in the living lab trajectory, and that the living lab project under scrutiny can be rather clearly distinguished from earlier or later innovation efforts. Questionnaires are ideally tested in a pilot measurement, and should contain not only quantitative measures, but, given the additionality and attribution issues, should necessarily be combined with qualitative information.

If repeated and extended in this way, the methodology and first estimations of the economic effects of living lab projects presented here may help companies and policy makers to decide on the appropriateness of living lab projects to achieve specific innovation goals. Conversely, it can also be expected that similar evaluations can help living labs to streamline and better define their offer.

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