Digital Supply Chain and Blockchain: a Living Lab Perspective

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Abstract. Living labs are not new. However, they are often framed in literature as methods for user-centric innovation management. We argue that a living lab can be seen as a research methodology within the field of cooperative inquiry, as an operationalisation of concepts such as action research and engaged scholarship. To do so, we present the case of a living lab in the Netherlands, focused on data sharing technologies, and analyse how it generates research output with clear pragmatic value as well as addressing interesting research challenges. Finally, the paper positions the methodology against existing concepts within cooperative inquiry.

Keywords: Living Lab, Action Research, Blockchain technology.

1 Introduction

Living labs are not new. For several years now they have been the focus of attention for academics in the field of innovation management [e.g. 1]. Typically, living labs are positioned as methods to generate innovation in a collaborative and participatory design with the final user of said innovation. However, little attention has been paid to the possibility of living lab to be an effective methodology to generate research results. Within the scope of cooperative inquiry methods (e.g. action research, collaborative frameworks) a living lab can provide fertile grounds for research involvement in a practical problem and succeed in generating pragmatic value that would otherwise be difficult to reach. To elaborate on this point, we aim at focusing on the specific case of Blockchain Technology (BCT). BCT revolves around the creation of decentralized systems, self-executing contracts and intelligent assets controlled over the internet and it is forecasted to lead to an influx of decentralised control over supply chains. Combined with innovative technologies (e.g. internet of things) BCT is expected to allow for improved information sharing, fostering trust and collaboration between companies, for the benefit of the entire supply chain. Several BCT-focused initiatives and consortia in the logistics and supply chain management areas have been launched in recent years, such as TradeLens, Batavia, we.trade and Marco Polo. Besides these initiatives, new and established technology providers (including TradeIX, Centrifuge, and Tradeshift), have started using BCT in the same areas.

Academic efforts are equally plentiful. For example, Treiblmaier [2] presents a framework for the development of BCT-based middle-range theories. Babich & Hilary [3] highlight academic challenges in the field of operations and supply chain management and focus on the need to regulate and govern the use of BCT within supply chains. Sternberg et al. [4] analyse BCT adoption for provenance of products, highlighting how attention towards the topic has so far translated in a scarcity of empirical evidence. Rogerson and Parry [5] recommends additional empirical evidence to be collected, with specific emphasis on longitudinal efforts.

In view of the difficulties that are presently experienced both practically (in effective adoption of an otherwise promising technology) and theoretically (in studying such adoption), we aim at provide evidence of how an alterative methodology, relying on the activities and results of a living lab focused on data sharing technology (including BCT) can provide insights on how to overcome existing obstacles and generate research results that are both of pragmatic value as well scientifically sound. Thus, our objective is to provide evidence of the relevance of living lab as research methodology, building on the practical case of a living lab in the Netherlands that aims at studying use case for data sharing in logistics and supply chain (including BCT adoption). By doing, we aim at expand the current view about existing theoretical perspectives on living lab [6] and reflect on the role of researchers in generating actionable and yet rigorous knowledge [7] within the domain of living labs, building on recent calls for leading and concurrent pathways from theoretical work to impact generation [8].

2 Literature review

A Living lab is design research methodology to tackle complex problems. It aims at tackling the innovation process cooperatively, involving the innovation user. The living lab is traditionally identified by three dimensions: (i) being a test-bed for innovation involving final users, (ii) being a setting for users to define innovations and (iii) being an innovation network [1, 6]. A Living lab aims to foster innovation, but a living lab in itself can also be seen as an innovative approach, within the domain of process innovation [9]. This attains to the way in which innovation should be organized so the desired outcomes will be realized. Although living labs are not a novel methodology for design research, further research should be conducted to gather a better understanding of the design of the living labs related to the desired outcomes [6, 10]. A living lab can be seen as a form of design methodology which is research-led and has a participatory mindset; within that scope the interaction with users can be either open or closed and the focus can be on value capturing or value creation: a value capturing strategy focusses on exploiting the potentialities of the existing technology. A value creation strategy aims at exploring opportunities provided by new technology [11]. In terms of practical structure a living lab tends to be characterised as open or closed: in an open living lab everyone has the right to participate, while a closed strategy has a limited accessibility because users who participate are pre-selected.

Looking to living labs in more detail, Hossain et al. [10] distinguishes seven key characteristics of living labs: Real-life environments; stakeholders; activities; business models and networks; methods, tools and approaches; challenges and outcomes. According to Wolfert (2010) the living lab approach incorporates the strengths of the prototyping approach because of its iterative method and the aim for a rapid development of a workable solution. A disadvantage of this approach is that essential steps in the development process can be left out. In general terms, living lab literature sees those instruments as either environment for stakeholders (including users) to evaluate and experiment with innovation, a methodology for generating innovation or as systems aspiring to gather feedback from various contexts and innovation activities [10]. The link between living labs and cooperative inquiry, such as action research, is not entirely new in literature [13], and the impact that a living lab can have on research, especially around applied sciences, is noted [14]. However, to the best of our knowledge this has not yet been fully addressed.

3 Methodology

As anticipated, this study relies on the activities of Spark!, a living lab located in the Netherlands and focused on developing use cases around the topic of data sharing innovation in logistics and supply chain management, including BCT. The Spark! Living lab focuses on investigating and developing use cases in the field of data sharing applied to physical assets in supply chain and logistics. Beyond practically developing these use cases together with the companies involved, a main goal is to build a repository knowledge for parties, especially SME's, that want to experiment with data sharing. The program started in 2019 will end in 2021. The living lab's work revolves around 'use cases', practical issues related to the topics object of the lab that are experienced by one or more companies within a supply chain. The use cases are developed by a project board and supported by a validation board composed of both practitioners and researchers. The execution is delegated to the project manager and the subproject leaders. The subproject leaders are managing the use cases. For each use case an innovation approach is carried out in four steps: ideate, analyse, develop prototype and run experiment.

Within the context of Spark!, researchers perform activities through action research [15, 16]. The study specifically focuses on one large corporate (called 'X' in short) within Spark!, which joined the Lab to evaluate the potential for data sharing (including evaluating BCT adoption) improvement in their supply chain. Despite being part of a global group, the use cases object of the analyses were focused on the European branch of the company. The corporate's European branch focused on processing and freezing food collected mostly from European suppliers and distribute it to European customer in the horeca industry. The company is involved in two use cases, which were put forward by management and refined together with researchers from the lab. Data collection took place in several different forms: (i) an initial 'intake interview' was performed with every company involved in the use case, in which to map out the company supply chain, operations and financial processes, as well as measure key variables such as relationship and level of trust with other supply chain members; (ii) interview have been performed by the research team with other relevant parties that will be influenced by innovation streaming from the work of the living lab, such as a customer of the corporate; (iii) per 'use case', meetings have been held periodically to discuss and present the advancements in the work, including both the research team and representatives from the companies involved in the use cases; (iv) a survey sent to the X's suppliers to acquire core information about their view in respect to the use case that was of their interest; (v) several site visits at different companies, to validate information acquired through other methods, map processes and perform basic ethnographic research. Data collection was intertwined with feedback sessions, either in plenary consortium meetings or with practitioners, to provide feedbacks on the data collected and discuss next steps, actions planned and implementation.

4 Analysed case

As discussed, the analysed case pertains to a food producer active in processing and freezing food for distribution to the horeca sector in Europe. Following the *'preliminary'* part of the cycle proposed by Maestrini et al. (2016), the research team first identified the appropriate areas for action. These were summarised in two use cases: on the supplier side the management of supplier certifications, and on the buyer side temperature management for condition goods.

4.1 Food safety certification

The first of the two analysed use cases pertains to certification for food safety. All direct suppliers of X are required (by current legislation) to provide a specific certificate attesting that they follow food safety requirements. The vast majority of suppliers are being certified by the same certification body. The certification process presents some clear challenges for the actors involved, namely: for X, an un-certified supplier cannot be included in the order scheduling. Considering that there appears to be some kind of seasonality in certification, X might find itself in the situation in which orders cannot be placed with several suppliers, since the due date for delivery falls after the expiration day of the certificates. For suppliers, a similar problem occurs. While on one side they might not be strongly incentivised to anticipate the renewal of a certificate (which cost money and results in certificate effectively lasting less than their nominal time span), they risk to loose orders from X. For the certification body, more transparency and visibility on the certification process will improve the quality of their services and provide an overall better experience to their direct customers (the supplier); it also means less time spent on managing request for additional information from X.

On top of this actor-specific challenges, all three parties lament that they have to spend time (and, thus, money) in calling, emailing and sharing information in unstructured manners, for example sharing Excel files with list of certified suppliers. This increases the probability of errors and the time required to properly manage the process. At the same time, it's unlikely that a simple online repository can serve the purpose of solving these issues. While the quality of the relationship between the parties cannot be described otherwise than very good, two issues are clear: (i) it remains a transactional principal-agent relationship and (ii) as the use case takes place within the European Union, the General Data Protection Reform (known as GDPR) applies. As such, privacy concerns are paramount: regarding point (i), there might be potential situations or cases in which a supplier might not want other parties to know the status of their certification process at a specific moment in time (for example due to issues that might cast doubts on their reliability); whether X accesses information about certification of a specific supplier (which likely include at least some data covered by GDPR), it should be with the explicit consent of that supplier.

More in general, a platform for data sharing of food certificates could be extended by all parties (X, certification body and suppliers) to multiple actors not involved in this specific use case, which makes the use of BCT more relevant and increase potential benefits. As such, the living lab focused on developing a prototype for a data sharing platform that allows the certification body to share food-safety certificates and other relevant information with X regarding the certification of X's suppliers, with the supplier's consent, with a certain degree of security (e.g. data immutability) provided by the adoption of BCT.

4.2 Temperature management for conditioned goods

The second use case pertains to measuring and monitoring temperature from the end of the production process (where the product is frozen) and the arrival of the product to the warehouse of the logistics service provider, where it is then stored for delivery to customers. The current temperature management process is managed by physically 'sticking' temperature sensor in the boxes of products at pre-defined moments in time (either by X or one of the LSPs), the employee responsible for the measurement (e.g. the truck driver) records the temperature on paper and, later on, in an excel file. The Excel files with all the temperature are not per se shared with the other supply chain partners, unless there is a specific complaint from the downstream supply chain (i.e. the horeca sector). However, those are reported to be extremely rare. However, two points do make the use case relevant for X and the involved parties: (i) there are discussion between X and the two LSPs with respect to the temperature the moment in which the products are taken over by the LSP. The contrast comes from actors wanting both to minimise the energy (and, sometime, time) spent to freeze products. X aims at providing products at the highest possible temperature, while the two LSPs aims at taking over products that are already at the lowest possible temperature; (ii) X aims at improving and extending its distribution network, including for example modal transportation including inland sea and rail as well as road. This very likely implies additional legal entities involved, as well as more loading and unloading, which might affect temperature of the products and make temperature tracking more difficult.

As such, the living lab setup an experiment focused on installing sensors for real-time temperature monitoring throughout the entire process from the end of the production line to arrival at the LSP warehouse, shared with interested parties. Although the experiment is still ongoing, it will allow for higher control over temperature and identification of issues related to temperature management.

5 Results and discussion

The high level of uncertainty that characterises the definition of the research problem tackled within the consortium affects both the research as well as the pragmatic results, and requires several iterations of the *'preliminary cycle'* to frame the problem correctly, meaning a constant reiteration between researcher and practitioners. This level of uncertainty is not limited to a potential lack of knowledge on a new phenomenon, as BCT can be, but is also a combination of other factors as, for example, the number of participants and the lack of visibility in the supply chain. It is a matter of *environmental uncertainty*.

A practical example comes from the second of the two use cases presented in the previous section. A first iteration with X led the research team towards the investigation of research possibilities within the temperature management from the LSP warehouse towards customers. Investigations with LSPs and customers led to the understanding that that process was not as critical as initially thought, and shifted the focus of the effort on the process between the end of production and the arrival at the LSP warehouse. Within this process, it was initially difficult to determine what the theoretical framework might be, meaning that the companies involved had a general 'hunch' that additional data could improve the process, but where not sure of what exactly could be done with additional data, or what specific mechanism could bring benefits. Thus a cycle of *'what can be done'* and *'what is useful'* was performed, to arrive to the definition of an experiment (in practical terms, not methodological) that could provide data and clarify to the involved parties the value of additional visibility on temperatures.

The second emerging perspective is related to the emerging of contradictions among actors in relation to the problem setting. Sometimes, parties simply have different perspectives that cannot be easily reconciled. For example, in the first of the two use cases there is a strong level of uncertainty regarding the behaviour of the other parties involved. After a first phase of relative alignment, X manifested some concern over a perceived lack of involvement from the side of the certification body, which they perceived as (potentially) opportunistic behaviour. A similar conflict revolves around involving suppliers: although they play a clear role in the use case, X and the certification body are both concerned about how and when to approach them. They are uncertain about their behavioural response. Even within X itself there are similar problems: suppliers relationship pass through key procurement employees that are, essentially, key account managers. Those stakeholders also present different perspectives than the managers involved in the living lab and are wary of opportunistic behaviour.

We see the presence of *behavioural uncertainty* as a limit to the pragmatic value of the research effort. In a more traditional approach (e.g. a case study) the detection of behavioural uncertainty could be, in itself, theoretically interesting and the focus of a potential contribution on, for example, understanding or explaining why BCT is adopted or not in a specific context. However, this would have limited pragmatic value, at least for the companies involved in the consortium. They are already aware that they are uncertain about other parties' behaviour, and don't need that to be explained to them. For them, the role of behavioural uncertainty in such pilots is clear and not difficult to predict, or understand. Therefore, behavioural uncertainty in this context becomes an obstacle to overcome to arrive to a problem definition that has pragmatic value for the companies involved. Arriving to a 'good' (meaning: both theoretically sound as well as pragmatically valuable) problem statement in this context implies an active effort from researchers to eliminate behavioural uncertainty, through direct involvement. In the specific case, feedback rounds and meetings with the different parties were specifically held, led by the research team, to work out differences in perspectives and limit the space for opportunistic behaviour, limiting behavioural uncertainty. This clarified the scope of the use case and led to identify a more pragmatically valuable research question, verting around understanding the role for digitalised data sharing on existing supply chain relationships.

5.1 Living lab as a research method

The issues illustrated in the previous section lead to the strengths of the living lab approach from a research methodology perspective. These revolve around two main issues.

The first relates to how is it possible to define a theoretical framework leading to pragmatic value when high levels of uncertainty affect the area of investigation. Essentially: how to define a theoretical framework, select a research question and collect data to answer it, when there is no indication of where actionable impact (to refer again Voss, 2020) is going to be, because the practitioners are – while research takes place – working on developing innovation. From a researcher that does not take into consideration cooperative inquiry, in such a case there are two possible outcome: either to focus on what can be measured at the present moment (which, however, is likely of little pragmatic value, as explained above) or wait, as an external agent to the innovation process, until the context is ready to produce actionable results (as explained by Voss, 2020, p. 539), which however disincentives researchers. In this sense, the involvement of researchers in the living lab for the specific purpose of 'using' the living lab as a methodology for research activities allows to go beyond this level of uncertainty (through back and forth communication, room to experiment, and so on) and address pragmatic value.

This first point, however, could be extended to other forms of cooperative inquiry, and is not unique of this specific case under analysis; however, a second issue is indeed unique. This relates to ensuring validity and reliability of the data collected. When the issue under investigation presents high levels of complexity and its area of application spans naturally over multiple actors in a supply chain, it's natural to inquire with more scrutiny whether data collected is valid and reliable. First of all, a topic such as BCT adoption requires multiple perspectives, even on the research side, to be fully understood: supply chain management, computer science and general IT management knowledge are critical to ensure that data collected is both valid and reliable. The living lab helps in this sense by naturally including in the same team researchers from different domains. Second, as actors in the supply chain provide from time to time conflicting perspectives, it is important to have the possibility to constantly go back to them with new evidence and test new ideas. This seems to be technically more difficult in a typical action research environment, in which you should move from data gathering to analysis, to action, to implementation, to feedback [15]. What if the data collected is contradicting in nature and cannot lead to action? This is a concept expressed by Maestrini et al. [17], that illustrate how the 'traditional' action cycle needs additional steps to account for the 'messy' relationship between a buyer and a supplier, leading to the 'action cycle reloaded'. We argue that this concept should be extended when the relationships are even more than the single buyer-supplier dyad, and that the living lab is the right structure to do so, as it provides the possibility to naturally cycle back at essentially every step of the action research process.

We are not aiming at reinventing the wheel. Our positioning of the living lab is well within existing conceptualisation of cooperative inquiry. Our view of a living lab as research methodology clearly builds on existing literature on action research, which in turns is seen as 'the most dominating approach' [18] within engaged scholarship, the general idea of collaboration within a learning to enhance scientific knowledge as well as pragmatic value [19]. Moreover, in our view the living lab is also closed to what is known as a *'collaborative research framework'* between academics and practitioners [20], or more generally to the concept of generating actionable knowledge in the field of innovation [e.g. 7]. However, we argue that the living lab is a specific operationalisation of these concepts that differ from the one presented in those contribution in the sense that it provides restricted capacity (working on a selected number of use cases, while Gastaldi and Corso [2013, p.76] mention working with 300 practitioners at the time) but at the same time focusing more on the specific use case, collecting in-depth data and allowing the process of building theory 'from the particular to the general in small steps', which is typical of action research [15].

In conclusion, what we argue is that a living lab is not necessarily, as depicted in literature so far, only a process of generating innovations in complex context, but that it has a role within cooperative inquiry methodologies for scientific research. It can, essentially, be used as a collaborative research framework to tackle specific research questions in areas in which there is a relatively high number of actors involved and high uncertainty in defining a theoretical framework. It allows to tackle uncertainty in the behaviour of supply chain partners and in the environment surrounding complex innovation processes through constant and repeated feedback between a multi-domain research team and practitioners involved in the process.

6 Conclusions

The main theoretical implication of our contribution lies in framing the living lab as a research methodology within cooperative inquiry. We provide some insights, based on the experience within one of those Labs, of the obstacles and insights that can emerge from adopting this perspective. In this sense, our practical implications relates to lesson learned in managing Spark!, which can provide useful insights for future endeavours of research teams that wishes to adopt a similar approach. The most relevant points can be summarised as followed: first, a critical issues arises in keeping stakeholders updated on the current situation of the projects. This is due to the volume and concurrency of the different activities going on at the same time within the Lab. The constant back and forth in one-on-one and consortium meetings that, on one side, allows for good data and good management, on the other side takes time and effort and, if not done properly, leads to disenfranchise of some stakeholders and limit the value of the overall effort. Second, the capacity of the lab is limited. In this sense, there is a clear trade-off between managing cases properly (also linking to the first point), so that the most valuable results (from both a practical and theoretical perspective) can be achieved, and extending the work to more use cases, which improve the chances for generalisability. Third, we made use of both graduate and undergraduate students in supporting and operative roles. This provides some relieve to the capacity issues, but on the other side leads to the involvement of students that, especially at the undergraduate level, have a tenure within the lab that is significantly shorter than the time required to reach most meaningful milestones. This implies that students are either involved in a research process that might not be self-contained or that they might have to step in mid-way through an existing process. Both of these lead to tension in managing the need for students to reach their own milestones (e.g. graduation) while at the same time provide useful work for the lab.

Finally, there are of course limitations. As the activities of Spark! are still undergoing, there's still unclarity on the final results that it can achieve, both practically and theoretically. This implies that our contribution at this stage cannot yet be fully supported by the empirical evidence coming from the activities of the lab. Moreover, even if Spark! would provide enough empirical evidence to support our claims, it would still be one single case, and our insights would have to be extended and validated in different settings.

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