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Exploring the link between free and open source software and the collaborative economy: A Delphi-based scenario for the year 2025

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ABSTRACT

Despite the growth experienced by the Collaborative Economy in recent years, there are still unexplored gaps within this phenomenon. One of the areas of study with scarce literature is linked with the impact of the Information and Communication Technologies based on collaborative environments, such as Free and Open Source Software, on the spread of the Collaborative Economy. Some questions are raised, such as: (1) To what extent do organizations linked with Collaborative Economy make use of Free and Open Source Software?, (2) What are the incentives that motivate the implementation of Free and Open Source Software in Collaborative Economy companies?, (3) What use do Collaborative Economy companies give to Free and Open Source Software?, and (4) Is there a greater use of Free and Open Source Software expected for the coming years among these organizations? To answer these questions, a study based on the Delphi method has been designed. To this end, a panel of 15 high-level experts in the field was formed. From the consensus of the experts, a significant role for Free and Open Source Software in the different collaborative components and industries is evident, with the current levels practically being maintained by the year 2025.

1. Introduction

Collaborative Economy (hereafter, CE) is a phenomenon at its peak that has exponentially grown over the recent years (Sibbritt, Volgger, Weber and Geneste, 2019; Faria, Gomes, Freitas and Vincenzi, 2019; Dredge and Gyimóthy, 2015), mainly due to the appearance of two conditions: (1) the fast diffusion of mobile technologies, specially smart-phones, and (2) the reduced number of entry barriers for start-ups (Lambert, Dedeurwaerdere, Nyssens, Severi and Brolis, 2019). Indeed, literature shows that the CE web-based business model uses mobile technologies and social networks to reach new commercial opportunities (Sibbritt, Volgger, Weber and Geneste, 2019), re-shaping the traditional value chain (Toni, Renzi and Mattia, 2018). Therefore, CE is the result of the development of commercial relationships in a peer-to-peer way, where three essential dimensions are identified: social, economic and technologic (Adornes and Muniz, 2019).

As a consequence of this rapid growth, the CE foundations are still being object of debate (Netter, Pedersen, Lüdeke-Freund, 2019), and it is receiving increased attention and generating new research themes. At present, the CE is considered the result of the confluence of two concepts already present in the literature: (1) sharing economy and (2) collaborative consumption (Ertz and Leblanc-Proulx, 2018; Ertz, Durif, Lecompte and Boivin, 2018; Gruszka, 2017). On the one hand, sharing economy occurs when "consumers conduct joint activities in the form of sharing resources with commercial implications" (Choi and He, 2019; p. 49) and, on the other hand, the collaborative consumption is considered to be "people coordinating the acquisition and distribution of a resource for a fee or other compensation" (Belk, 2014).

It must be recognized that both forms of commerce have always been present throughout all stages of the history of the economy, although nowadays are carried out on a large scale owing to the development of technology (Adornes and Muniz, 2019; Sutherland and Jarrahi, 2018). In that sense, CE has created a new system of production and consumption that permits the exchange of goods and services reducing the informative asymmetries and transaction costs (Fehrer et al., 2018; Belk, 2014). Indeed, this aspect has drawn many companies to find new business opportunities. It is the case of Airbnb. This company has spread exceedingly reaching some highlighted milestones in 2019, such as six million listings around the world and had hosted 500 million stays (Guttentag, 2019).

In the field of Information and Communication Technology (hereafter, ICT) there can also be identified some phenomenons supported on

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a collaborative base as in the case of Free and Open Source Software (hereafter, FLOSS). Generally, FLOSS has achieved enormous popularity due to three factors (Cheruy, Robert and Belbaly, 2017): (1) user-developer interaction; (2) market potential; and (3) development stage. Two key features of FLOSS are highlighted (Behfar, Turkina and Burger-Helmchen, 2018; Sutanto, Kankanhalli and Tan, 2014): (1) it is developed in a public and collaborative manner; and (2) the source code is accessible for users, and they can change it, and in most cases, distribution is even allowed. Therefore, FLOSS is considered a viable alternative to proprietary software for many institutions (Scacchi et al., 2006Joia and Vinhais, 2017; Spinellis and Giannikas, 2012; Colford, 2009), becoming a global innovative movement where different social, economic and public agents collaborate, united by the need to control the software design (Gamalielsson and Lundell, 2014).

While the number of studies focused on the CE and ICT has increased in recent years (Ertz and Leblanc-Proulx, 2018), the relationship between the CE and FLOSS has been scarcely explored, despite sharing a similar collaborative environment. This study attempts to fill this gap. Concretely, the general aim is to analyse to what extent FLOSS is present in the activities that form the so-called CE and what will be the degree of implementation in the middle term. Therefore, being FLOSS the essential element of the collaborative knowledge, it will be stated whether there is a collaborative feedback in this sense.

Specifically, four objectives are identified. Firstly, to find out the current level of implementation of FLOSS in the six key components (collaborative consumption, collaborative production, collaborative finance, collaborative knowledge, collaborative governance and value co-creation) that form the CE and its main sectors of business activity. Secondly, to find the motivational and impeding factors for the use of this technology in collaborative organizations. Third, to ascertain what applications collaborative organizations will give to this software. Finally, to do a forecasting analysis regarding the application of CE by components for the year 2025.

Because of the novelty and nature of the objectives, the application of the Delphi methodology has been chosen. In that sense, this technique, of a qualitative nature, is recommended when there is insufficient information available for decision-making or it is necessary, for our investigation, to collect consensual and representative opinions of a collective of individuals (Dalkey and Helmer, 1963). The Delphi technique is a structured methodology to systematically collect expert judgments about a problem, process information and through statistical resources, build a general group agreement, which allows transforming the individual assessments of the experts into a higher collective judgment (Riggs, 1983). The questionnaires are presented in the form of an iterative and anonymous consultation procedure through surveys.

The study is structured as follows. Section 2 provides the theoretical framework where it is analyzed the concept of CE and its different components, the history of software and usages of FLOSS in CE. Section 3 presents the methodology. Section 4 discusses the findings that emerged from the analysis. Finally, conclusions addressing the implications of the findings and possible directions for future research are given in the Section 5.

2. Theoretical framework

2.1. The collaborative economy (CE)

The CE is a partially novel phenomenon (Fehrer et al., 2018). Basically, according to Longhurst et al. (2016). it is considered "an economy organised around peer-to-peer principles which facilitates reuse, sharing and builds social capital" through the use of "Sharing and collaborative platforms as a key form of economic distribution". Recently, as a consequence of technological advances, on-line platforms associated to the CE have been developed to incentive collaborative behaviors. In fact, despite of this sort of economy already existed before on a small scale, this phenomenon has extended quickly and greatly. Originally, it emerged in the USA, spreading all over the world, especially to Europe (Richards, Brown and Dilettuso, 2019).

Due to this accelerated growth, at present, it is not simple to find a consensus in relation to the concept and foundations. Traditionally, this term has been used to refer to a wide variety of activities and is usually related to a combination of factors, such as technological development, economic recession, environmental crisis, and a certain change of values in contemporary societies (Gössling and Hall, 2019; Ioannides, 2018). As a matter of fact, it is usually considered as a heterogeneous movement that combines a set of modes of production and consumption by which agents share underutilized assets, goods or services, in exchange or not for a monetary value, using digital social platforms and, in particular, the Internet (Weber, 2016; Pattinson, 2016). Thereby, the CE allows on the one hand, to reduce the information asymmetries, and transaction costs, and, on the other hand, to increase the scale at which they are carried out.

The CE is confluence of some activities. In effect, six scopes or key components can be identified in the CE (Alonso and Miranda, 2017): (1) collaborative consumption, (2) collaborative production, (3) collaborative finance, (4) collaborative knowledge, (5) collaborative governance and (6) value co-creation.

2.1.1. Collaborative consumption

Collaborative consumption is the most visible activity of the CE. Felson and Spaeth (1978) were the first to use the term of collaborative consumption. Thenceforth, this topic has grabbed the attention of numerous investigations, especially since the explosion of the technology, in very diverse industries of the economy (Sibbritt, Volgger, Weber and Geneste, 2019), such as travel, car-sharing, finance, staffing, and music/video streaming (Lindblom, Lindblom and Wechtler, 2018), among others. It is considered as a reinvention of traditional market behaviors, such as bartering, rental, trade, and exchange, which thanks to technology can now be developed on a scale and in a way never seen before (Botsman and Rogers, 2010).

Over the last few years, there has been a worldwide tendency of promoting a consumption based on collaboration and the use of idle goods, as well as a trend towards a more reasonable use of goods (Fraanje and Spaargaren, 2019). Thus, the collaborative perspective has meant a redefinition of consumption, which goes from being understood as property to considering it as access and use (Park and Armstrong, 2019). Examples of collaborative consumption on-line platforms are car sharing such as Avancar, car rental like SocialCar, sharing routes such as BlaBlaCar, rental accommodation such as Airbnb, or the sale of second-hand objects such as Wallapop, among many others (Huber, 2017; Casprini, Di Minin, and Paraboschi, 2019; Abbes, Hallem and Taga, 2020).

2.1.2. Collaborative production

Also known as peer-to-peer production, collaborative production is referred to the "groups or networks of individuals collaborate to design and produce goods" (Stokes, Clarence, Anderson and Rinne, 2014). In this way, collaborative production allows to a business network to share in an effective and efficient manner production resources based on collaborative resource sharing system (Ko and Nof, 2012). Considering this aspect, three principles are identified in the collaborative production (Levalle, Scavardab and Nof, 2013): (1) cooperation requirements planning, (2) conflict and error detection and prognostics, and (3) fault tolerance by teaming.

Precisely, in this component of the CE is found the closest relationship between the two topics analyzed in the present study. Literature has always considered FLOSS the clearest example of collaborative production.

2.1.3. Collaborative finance

The financial industry is one of the most affected by the collaborative revolution (Li, Hao, Zhang and Xiong, 2018). Collaborative finance has

emerged as an alternative financing system to support entrepreneurial ventures and small businesses, allowing to find new ways of financing and investment outside the traditional financial institutions (Cumming, Deloof, Manigart and Wright, 2019; Cumming and Groh, 2018). Three modalities are identified (Liu, Shang, Wu and Chen, 2020; Wonglimpiyarat, 2018; Hu, Bhuyan and Feng, 2012): (1) crowd funding, (2) peer-to-peer lending, and (3) currency exchange.

The main example of collaborative finance is found in crowd funding platforms, which is nothing more than direct and mass financing of a specific project (Ellman and Hurkens, 2019). In this case, people contribute funds in exchange for a monetary, non-monetary consideration or paying in advance for the product or service that the promoter will launch (Cumming, Johan and Zhang, 2019). Moreover, peer-to-peer lending systems allow to connect those who wish to invest with those who need a loan, or collective insurance policies (Milne and Parboteeah, 2016). Additionally, platforms are identified whose purpose is to transfer and exchange of currencies in a collaborative way, e.g., Transferwise or MoneyGram (Hashemi Joo, Nishikawa and Dandapani, 2019). Other variants can be social currency and digital crypto currency, which create new forms of value exchange (Trudeau and Shobeiri, 2016).

2.1.4. Collaborative knowledge

The importance of collaborative knowledge in the economy has been highlighted by many authors (Archer-Brown and Kietzmann, 2018; Morell, Salcedo and Berlinguer, 2016; Pedersen, 2015). In fact, they all affirm that open knowledge represents the foundations of the CE. Thus, the author points out that the quick development and great impact of the CE have only been possible thanks to the fact that many of the people leading such projects use open practices and tools that allow CE models to grow and distribute much faster than they would in a traditional capitalist economy.

2.1.5. Collaborative governance

Collaborative governance or open governance aims to activate mechanisms that enables continuous communication between governments and citizens to make decisions in response to their needs, allowing better services in an open and transparent way (Djosetro and Behagel, 2020). In this sense, Ma, Lan, Thornton, Mangalagiu and Zhu (2018) suggest that collaborative governance can improve the agility to integrate social and economic actors in the CE, ensuring its efficacy, resilience, and sustainability.

2.1.6. Value co-creation

According to Shulga, Busser and Bai (2018) “value co-creation is defined as the joint, collaborative, concurrent, peer-like process of producing new value, both materially and symbolically, through voluntary contributions of multiple actors resulting in reciprocal well--being”. Therefore, it is referred to as emergence of new ways of exchanging value, alien to the transmission of money (Wang and Ho, 2017). In addition, value co-creation has changed the consumer conception from passive to active actors (Jin, Kong, Wu and Sui, 2018; Zorina, 2016).

Time banking could be considered a way of value co-creation system. It is a community exchange network where services are exchanged for time rather than money (Kakar, 2018). Furthermore, it is seen as a social innovation where members self-organize regarding the offers and requests using a specific software or by a time bank coordinator (Avelino et al., 2019). There are several communities around the world that have their own time bank, among which two examples to be highlighted are it can Time-republik or TimeOverflow (Godelnik, 2017).

2.2. FLOSS and the CE

FLOSS enables access to the system software regardless of associated price or cost (Gallego, Racero, Bueno and Noyes, 2015). Additionally, FLOSS is a movement focused on communities of users who do not belong to typical software development roles (Slee, 2016). In fact, the number of communities is growing, and it may continue to grow in the forthcoming years on account of FLOSS becoming a viable alternative to proprietary software (Shahrivar, Elahi, Hassanzadeh and Montazer, 2018). Recent studies legitimise FLOSS as a competitive movement in the world of the software industry (Schaarschmidt et al., 2015; Sarrab and Rehman, 2014; Reisinger et al., 2014). Moreover, this movement is based on the participation and collaboration (Wei et al., 2014). Precisely, this collaboration provides significant learning and legitimacy-building opportunities (Stam, 2009). Furthermore, participants in FLOSS design can potentially be involved in all the phases of the design process (Barcellini et al., 2009).

Two main motivations for the development of this type of software are identified. On the one hand, an ethical motivation inasmuch as FLOSS is part of the knowledge and it must spread without hindrance. On the other hand, a pragmatic motivation based on technical and economic advantages that FLOSS can generate (Yildirim and Ansal, 2011). It should be noted that FLOSS has been successful in the business field, some companies initially opposed to the movement changed their vision over time, as was the case with IBM in the 1990s (Campbell-Kelly and Garcia-Swartz, 2009).

Companies can make FLOSS their business model, obtaining benefits, for example, through the installation, service, and support of FLOSS or through the sale of proprietary product versions and extensions (Perr, Appleyard and Patrick, 2010). Stallman(Stallman, 2002, 2009) himself acknowledges that his main source of income was his remuneration as a FLOSS technical assistant. However, not only does FLOSS benefit those companies that use it as a business, but many other companies, from many different industries, which have taken advantage of FLOSS.

Although FLOSS takes place in numerous companies, the relationship between FLOSS and CE has been poorly analyzed regarding the six components previously described. Both, FLOSS and CE, share the same collaborative perspective. This aspect has had a certain reflection in the literature, mainly as to the components of collaborative production, knowledge and collaborative governance. Instead, collaborative consumption, collaborative finance and value co-creation have been sparsely treated.

In this sense, Troxler (2010) considers that collaborative production is widely applied in FLOSS development, within which, is the use of the Linux operating system and the Apache web server, are the most outstanding examples (Tabarés Gutiérrez, 2018; Benkler, 2016). An example of collaborative production is the case of Arduino, a company that designs and manufactures hardware development boards, distributing its products as Hardware and Free Software, through a GNU license. Other examples of collaborative production are FabLabs, Shapeways, LocalMotors, Wikispeed, WikiHouse, OpenStructures, OpenDesk, OpenStreetMap or Nimber.

Collaborative knowledge is key in the present study due to FLOSS is based on open knowledge. Through open knowledge it is possible to carry out initiatives that contribute to free access to information, research and learning production (Zhitomirsky-Geffet, 2019; Frederick, 2016; Borjigen, 2015). In this sense, Fuster and Dimmons (2018) indicate that FLOSS “is not just an alternative to proprietary software: free software, unlike proprietary software, is part of a digital commons available to everyone".

A clear example of collaborative knowledge are Wikis. This type of software facilitates the creation and edition of collaborative websites while enhancing community websites (Mayordomo and Onrubia, 2015). This is the case of Wikipedia. This collaborative website allows the exchange of knowledge from which to build the content in a crowd-sourcing manner (Arndt, Naumann, Radtke, Martin and Marx, 2019). Wikipedia is developed by MediaWiki, a FLOSS whose license is under the standard of the GNU (General Public License) and is used for all Wikimedia projects. In addition, there are identified other manifestations of open knowledge, such as the Creative Commons licenses, the

Open Source Hardware Association, the Open Knowledge Foundation, or the Open Access movement (Castro, Putnik, Castro and Fontana, 2019; Dobusch and Kapeller, 2018; Clark, 2017).

FLOSS and collaborative governance have a close relationship. While the FLOSS movement has an ethical and economic sense when it creates software sharing their source code and delivering it to the community for its development and use, the collaborative governance seeks to open the operating code of the governments and states, returning the code of control of these sources to the community so that, in this way, it is constantly evolving. In fact, open governance has incorporated the principles of the FLOSS movement. According to Barns (2018) the "shareable and re-usable code has served as the basis for improved software products to rethink the role and design of public institutions". An example of open governance platform is FixMyStreet. It is based on FLOSS technologies, and it allows citizens to expose problems they have detected in the streets, hence solving them (Nik-Bakht and El-Diraby, 2016).

With the above, evidence of the use of FLOSS within collaborative organizations can be certainly observed, however, the literature that addresses the issue is scarce. On this aspect, several questions are raised, such as: (1) To what extent do organizations linked with CE make use of FLOSS?, (2) What are the incentives that motivate the implementation of FLOSS in CE companies?, (3) What use do CE companies give to FLOSS?, and (4) Is there a greater use of FLOSS expected in the coming years in these organizations? To answer these research questions, the Delphi method has been applied.

3. Methodology

The Delphi method has been applied in multiple fields, especially in ICT and innovation studies (Gallego and Bueno, 2014). It is precisely recommended for investigations in certain fields where there is barely any historical data (Devaney and Henchion, 2018) or when experts struggle to attend work sessions (Linstone and Turoff, 2002). It is considered a structured methodology to systematically collect expert judgments about a problem, process information and, through statistical resources, build a general group agreement. In addition, it is a methodology of a forecasting purpose (Flostrand, Pitt and Bridson, 2020; Gallego and Bueno, 2014).

In a general way, this technique enables the possibility of studying and analyzing the social, technological, and economic future (Von der Gracht, 2012; Landeta, 2006) thanks to the systematic use of an intuitive trial, issued by a group of experts (Linstone and Turoff, 2002). In fact, the Delphi method is the most appropriate one in the present study, to the extent that not only it allows analyzing the degree of current implementation of FLOSS in the CE, but also gives an idea of the trajectory that is expected to experience in the next years.

In this respect, Dalkey (1969) establishes four defining characteristics of the Delphi method: (1) iteration, (2) anonymity, (3) controlled feedback and (4) statistical analysis. It is an iterative process because the experts participating in the process must express their opinion more than one, through several rounds that lead to stabilize the opinions (Munier and Rondé, 2001). On the other hand, this method is characterized by anonymity since the different experts who will collaborate in the investigation will not know the identity of the rest (Linstone and Turoff, 2002). The third feature is controlled feedback, to the extent that the researcher is the one who analyses the responses received and produces the new query, allowing participants to know the perspectives of the rest and they are given the opportunity to clarify or change their opinions. (Skulmoski, Hartman and Krahn, 2007). Finally, the Delphi method is characterized by statistical analysis, with the most used statistics being the mean, median, mode, maximum, minimum, standard deviation, and quartiles (Gallego and Bueno, 2014).

3.1. Application of the method

The Delphi method has been structured following the proposal of Belton, MacDonald, Wright and Hamlin (2019) about the six steps of a successful Delphi application. The research issue and the questions that will be asked to the experts are defined, in addition to determining the number of rounds that will be carried out (Linstone and Turoff, 2002). Subsequently, the panel of experts is determined and contacted. Once the acceptance of the experts regarding their participation has been received, the questionnaires are sent to them and once they are completed, the information of the first round is analyzed and the next round of feedback is prepared and consulted as many times as necessary to produce the consensus / dissent that responds to the objectives of the study (Von der Gracht, 2012). Finally, the results obtained through the statistical resources are analyzed.

The consensus is asserted when most of the opinions of the panel are included within the interquartile range or when there is no significant divergence among the expert́s perception (Von der Gracht, 2012; Linstone and Turoff, 2002; Rowe and Wright, 1999). The questions in the second round were the same as in the first round, although, in this time, each expert was given the answers, which they formulated in the first round and the aggregate group responses (median, mean and standard deviation).

3.2. Panel of experts

The selection of the expert panel is key in the Delphi method. In this respect, it must meet two premises: (1) the participation of experts with proven experience in the matter, and (2) the heterogeneity of the panel is essential to reach the validity of the findings. The heterogeneity is usually refereed to divergent levels of knowledge, or it is determined by variables such as sex, geographical location, age, among others (Parente and Anderson-Parente, 2011; Linstone and Turoff, 2002). Depending on the heterogeneity or homogeneity of the experts, the required size could be different. In a general way, the more heterogeneous a panel is, the fewer experts are needed.

In the development of the present investigation, 25 experts in the field were invited to take part in the two rounds Delphi study. To guarantee the reliability of the study, and meet the specific objectives set, the selected experts cover the entire spectrum of the CE (consumption, production, knowledge, governance, finance, and value co-creation), including engineers, consultants, researchers, inspectors, and CEOs. Of the total number of invitations, 15 experts agreed to participate in the study, to whom the method and its intervention in anonymous group assessment and group statistics were explained. This response level is in line with other studies that have applied the Delphi method (Belton, MacDonald, Wright and Hamlin, 2019; Worrell, Di Gangi and Bush, 2013).

There are no specific rules regarding the number of experts that must participate. The size of the panel of experts should range between 6 and 30 depending on the problem posed and always giving priority to quality over quantity (Gallego and Bueno, 2014). In view of this, it can be considered that 15 experts are acceptable for the panel, so it can be affirmed that the range of participation of experts in the present study allows affirming the validity of the results. Table 1 shows the demographic profile of the experts.

3.3. Rounds and questionnaire

A study with two rounds has been defined to apply the Delphi method. Indeed, studies focus on the foundations of the Delphi technique suggest that the suitable number of rounds could be two or three (Rowe and Wright, 2001; Rowe and Wright, 1999). In this respect, most studies that use the Delphi method in the field of ICT applied the Delphi method based on two rounds (Gallego and Bueno, 2014).

To carry out the method, a web questionnaire was used, whose URL

Table 1
Demographic profile of the experts.

Dimension	Number	%
Gender		
Male	13	86.6%
Female	2	13.4%
Total	15	100.00%
Age		
26-29	1	6.67%
30-39	3	20.00%
40-49	11	73.33%
Total	15	100.00%
Position		
Public Administration Inspector	1	6.67%
CEO	2	13.33%
Telecommunications engineer	1	6.67%
Researcher	5	33.33%
Executive Director of ICT	1	6.67%
Digital entrepreneur	1	6.67%
Social entrepreneur	1	6.67%
Consultant	1	6.67%
Project manager	1	6.67%
Software engineer	1	6.67%
Total	15	100.00%

link was sent to the experts by email. The objective of the first questionnaire is to calculate the interquartile range, while the second provides each expert with the opinions of their colleagues, thus opening a transdisciplinary debate, to obtain a consensus on the results and a generation of knowledge on the subject (Hsu and Sandford, 2007).

The questionnaire has been designed to cover the specific objectives of the study. In this way, the questionnaire has been divided into four sections (Table 2). The first section is intended to define the current level of implementation of FLOSS in the different components and industries that make up the CE. The selection of components and industries has been carried out according to the theoretical framework. To assess the implantation in the components, the experts were given a percentage scale in 10% increments, while in the industries questions, a range of responses between 1 and 7 was chosen (7-Point Likert Scale). Further, the experts had an open field to insert any comments.

The second section of the questionnaire focuses on the study of the main motivational and impeding aspects of the use of FLOSS in the CE. For the preparation of this second section, part of the factors considered in the study by Gallego, Bueno and Luna (2008) regarding the dissemination of FLOSS has been taken as a reference. Experts were asked to rate from 1 to 7 (7-Point Likert Scale) the different motivational and impeding aspects listed in the results table.

The third section is intended to deal with about the application of FLOSS in the different collaborative areas. In this section, multiple-choice questions splitted by collaborative components are offered to experts to determine the use of FLOSS. Finally, the fourth section, like the first, aims to find out the level of implementation in the different components and industries of the CE, but in this case prospectively by the year 2025. Again, a percentage scale in 10% increments is used for the components and 7-Point Likert Scale for the industries.

In the second round, each expert was given their response to the previous round, together with the median and standard deviation resulting from the first round, so that taking these values into account they would answer the questionnaire again. It is important to mention that the consensus was reached in the second round; it is for this reason that it has not been necessary to make successive rounds. When assessing this consensus, the median interpolated has been observed, since several authors, including Gallego, Bueno and Luna (2008), consider that with it, greater precision is obtained in the estimates.

4. Results and discussions

The objective of this section is to present the results obtained after the application of the Delphi method. In this particular, the findings show a null or weak consensus in many variables in the first round, although a consensus began to appear in some items (Table 3). We must remember that the consensus is affirmed when most of the opinions of the panel are included within the interquartile range or when there is no significant divergence among the expert́s perception. Thus, a second round is required in the present study.

Once the second round was completed, the consensus was robust and significant. In fact, most responses in all variables were within the interquartile range and the standard deviations were reducing. Hence, no new rounds were necessary.

In this manner, this section shows the results of the consensus reached in the second round once the median of the responses in each question is found between Q1 and Q3 quartiles. In addition, it is important to highlight the participants were eminences and pioneer people in the field of the CE, which grants the results a greater rigor.

4.1. Current implementation scenario of FLOSS by CE components

In the first section of the questionnaire, experts were asked about the level of current implementation of FLOSS in the components of the CE by industries. The results agreed in the second round are reflected in Figs. 1 and 2, which shows the median obtained at each item.

First, it can be observed that experts agree that the component of collaborative knowledge is the one that makes the most use of FLOSS, having obtained a score of 90%. It is followed by the collaborative production component and value co-creation with 70%. These results are in line with the theoretical background revealed in Section 2, when the literature stablished that the component of knowledge and production are the ones that have most visibly exposed the use of FLOSS. It is convenient to highlight that collaborative software is within the component of collaborative knowledge, so it is not surprising that FLOSS is used to a greater extent in the component which it belongs to.

Secondly, in terms of value co-creation, where time banks are mainly located, although it is not one of the most important components within the CE, since its development is scarce in relation to the rest, it does seem to be one of the most used FLOSS. Finally, in collaborative consumption, collaborative finance and open governance, the level of implementation of FLOSS is considered to be about 60%. One of the experts highlighted the Decidim project within the open governance, for which the use of FLOSS has been applied. In this sense, all these results reflect that the degree of implementation of FLOSS in the collaborative components is high, ranging between 60% and 90% of implementation, leaving room for a future increase.

Regarding the level of implementation by industries, the results maintain a close relationship with those obtained in the components, since the industry that has been valued with a higher degree of implementation of FLOSS is the education industry with 80%. This is followed by the transport and logistics industry and the food and agriculture industry with 50%. One of the experts sets an example within the food industry, the Katuma platform, which implements Free Software, as well as the OpenFoodNetworks platform, developed from open source.

For the rest of the collaborative components the assessment has also been positive but below 50%, the experts reflecting a consensus on 40% implementation in the banking, health, tourism, energy, real estate, and manufacturing industries.

4.2. Motivational factors and obstacles for the use of FLOSS in the CE

In this section the results regarding the motivational aspects and barriers of the use of FLOSS in the CE are highlighted. It is especially important to take these factors into account, as they justify the results of the current implementation of FLOSS in companies and collaborative organizations. The results agreed in the second round are reflected in Figs. 3 and 4.

The experts believe that the most relevant motivational factors when

Table 2
Questionnaire.

Item											
	Section 1: Current implementation of FLOSS in the collaborative economy										
	1.1. Rate the percentage of current FLOSS implementation of the different collaborative areas **(%)**										
1.1.1	Collaborative consumption	10	20	30	40	50	60	70	80	90	100
1.1.2	Collaborative production	10	20	30	40	50	60	70	80	90	100
1.1.3	Collaborative knowledge	10	20	30	40	50	60	70	80	90	100
1.1.4	Collaborative finance	10	20	30	40	50	60	70	80	90	100
1.1.5	Open governance	10	20	30	40	50	60	70	80	90	100
1.1.6	Value co-creation	10	20	30	40	50	60	70	80	90	100
	1.2. Rate the percentage of current FLOSS implementation of the different collaborative industries **(%)**										
1.2.1	Banking, insurance, and consultancy	10	20	30	40	50	60	70	80	90	100
1.2.2	Health	10	20	30	40	50	60	70	80	90	100
1.2.3	Transport and logistics	10	20	30	40	50	60	70	80	90	100
1.2.4	Tourism and leisure	10	20	30	40	50	60	70	80	90	100
1.2.5	Energy	10	20	30	40	50	60	70	80	90	100
1.2.6	Real estate and construction	10	20	30	40	50	60	70	80	90	100
1.2.7	Manufacturing	10	20	30	40	50	60	70	80	90	100
1.2.8	Food and agriculture	10	20	30	40	50	60	70	80	90	100
1.2.9	Education	10	20	30	40	50	60	70	80	90	100
	Section 2: Motivational aspects and obstacles to the use of FLOSS in the collaborative economy										
	2.1. Assess the extent to which the following factors favor the implementation of FLOSS in collaborative economy companies and organizations										
2.1.1	Cultural change oriented to accept FLOSS	1	2	3	4	5	6	7			
2.1.2	Perceive FLOSS as quality software	1	2	3	4	5	6	7			
2.1.3	Possibility to participate from the FLOSS community	1	2	3	4	5	6	7			
2.1.4	Trust in the FLOSS community	1	2	3	4	5	6	7			
2.1.5	Interest of end users	1	2	3	4	5	6	7			
2.1.6	The end users are programmers	1	2	3	4	5	6	7			
2.1.7	Promotion and support of management	1	2	3	4	5	6	7			
2.1.8	Perception of savings in acquisition and adoption costs	1	2	3	4	5	6	7			
2.1.9	Reduced user dependence on the software provider	1	2	3	4	5	6	7			
2.1.10	Consider FLOSS a competitive advantage	1	2	3	4	5	6	7			
2.1.11	Greater funding for FLOSS projects	1	2	3	4	5	6	7			
2.1.12	Information on requirements for FLOSS implementations	1	2	3	4	5	6	7			
2.1.13	Possibility of adapting the FLOSS software	1	2	3	4	5	6	7			
2.1.14	Greater ease in detecting security irregularities	1	2	3	4	5	6	7			
2.1.15	Compatibility of FLOSS with other software	1	2	3	4	5	6	7			
2.1.16	FLOSS compatibility with hardware	1	2	3	4	5	6	7			
	2.2. Assess the extent to which the following factors hinder the implementation of FLOSS in collaborative economy companies and organizations										
2.2.1	Resistance to change	1	2	3	4	5	6	7			
2.2.2	Insufficient skills or experience	1	2	3	4	5	6	7			
2.2.3	Lack of strategic, management or support plans	1	2	3	4	5	6	7			
2.2.4	Existence of infrastructure problems	1	2	3	4	5	6	7			
2.2.5	Lack of resources	1	2	3	4	5	6	7			
2.2.6	Insufficient legal system	1	2	3	4	5	6	7			
2.2.7	Uncertainty or lack of information	1	2	3	4	5	6	7			
2.2.8	Lack of relevant and quality information	1	2	3	4	5	6	7			
2.2.9	Security issues associated to source code accessibility	1	2	3	4	5	6	7			
2.2.10	Insufficient source code quality	1	2	3	4	5	6	7			
2.2.11	Incompatibility with legacy systems	1	2	3	4	5	6	7			
2.2.12	High failure rate	1	2	3	4	5	6	7			
2.2.13	System complexity	1	2	3	4	5	6	7			
2.2.14	Training costs	1	2	3	4	5	6	7			
2.2.15	The effects of trends	1	2	3	4	5	6	7			
2.2.16	Problems with suppliers	1	2	3	4	5	6	7			
2.2.17	Lack of market acceptance	1	2	3	4	5	6	7			
	Section 3. Type of FLOSS use in collaborative organizations										
	3.1. Select the most types of FLOSS implementation in collaborative consumption companies and organizations (multiple-choice)										
	Internal use of FLOSS	(1)	(2)	(3)	(4)	(5)	(6)				
3.1.1	FLOSS use in the source code of the collaborative platform	☐	☐	☐	☐	☐	☐				
3.1.2	Source Code Development Tools	☐	☐	☐	☐	☐	☐				
3.1.3	Management and administration systems	☐	☐	☐	☐	☐	☐				
3.1.4	Database	☐	☐	☐	☐	☐	☐				
3.1.5	Project management software	☐	☐	☐	☐	☐	☐				
3.1.6	Office tools	☐	☐	☐	☐	☐	☐				
3.1.7	None	☐	☐	☐	☐	☐	☐				
	FLOSS Distribution	(1)	(2)	(3)	(4)	(5)	(6)				
3.1.8	Distribution of the entire source code under FLOSS license	☐	☐	☐	☐	☐	☐				
3.1.9	Partial distribution of the source code under FLOSS license	☐	☐	☐	☐	☐	☐				
3.1.10	Tools distribution outside the main activity under FLOSS license	☐	☐	☐	☐	☐	☐				
3.1.11	No type of distribution	☐	☐	☐	☐	☐	☐				
3.1.8	Distribution of the entire source code under FLOSS license	☐	☐	☐	☐	☐	☐				
3.1.9	Partial distribution of the source code under FLOSS license	☐	☐	☐	☐	☐	☐				
3.1.10	Tools distribution outside the main activity under FLOSS license	☐	☐	☐	☐	☐	☐				
	Section 4: FLOSS in the collaborative economy in 2025										
	4.1. What do you think the percentage of FLOSS implementation will be in 2025 in the different collaborative pillars? (%)										
4.1.1	Collaborative consumption	10	20	30	40	50	60	70	80	90	100
4.1.2	Collaborative production	10	20	30	40	50	60	70	80	90	100

(*continued on next page*)

Table 2 (*continued*)

4.1.3	Collaborative knowledge	10	20	30	40	50	60	70	80	90	100
4.1.4	Collaborative finance	10	20	30	40	50	60	70	80	90	100
4.1.5	Open governance	10	20	30	40	50	60	70	80	90	100
4.1.6	Value co-creation	10	20	30	40	50	60	70	80	90	100
4.1.1	Collaborative consumption	10	20	30	40	50	60	70	80	90	100
4.1.2	Collaborative production	10	20	30	40	50	60	70	80	90	100
	4.2. What percentage of FLOSS implementation do you think the following collaborative sectors will have in 2025? (%)										
4.2.1	Banking, insurance, and consultancy	10	20	30	40	50	60	70	80	90	100
4.2.2	Health	10	20	30	40	50	60	70	80	90	100
4.2.3	Transport and logistics	10	20	30	40	50	60	70	80	90	100
4.2.4	Tourism and leisure	10	20	30	40	50	60	70	80	90	100
4.2.5	Energy	10	20	30	40	50	60	70	80	90	100
4.2.6	Real estate and construction	10	20	30	40	50	60	70	80	90	100
4.2.7	Manufacturing	10	20	30	40	50	60	70	80	90	100
4.2.8	Food and agriculture	10	20	30	40	50	60	70	80	90	100
4.2.9	Education	10	20	30	40	50	60	70	80	90	100

Note:
(1) Collaborative consumption
(2) Collaborative production
(3) Collaborative knowledge
(4) Collaborative finance
(5) Open governance
(6) Value co-creation

adopting FLOSS by collaborative organizations are quality, being able to participate and benefit from the FLOSS community, that a substantial number of end users are programmers and, of course, the possibility of adapting the software to the needs of organizations. In relation to the latter factor, it should be remembered that thanks to FLOSS, the source code can be accessed, and all the necessary modifications can be made, so this last motivational factor is common for all FLOSS users, not only in a collaborative environment.

It is also highlighted the technical importance that is given to FLOSS in the collaborative field, valuing its quality and the fact that part of the collaborative platforms are programmers. The latter factor shows that part of the users of collaborative platforms have computer skills. These results are not surprising based on the theoretical background, especially considering that two of the great components of the CE are knowledge and production, components in which computer science has a decisive role. However, one of the experts highlighted that there are relevant projects using FLOSS where users are not software engineers.

It is also not surprising that among the factors with the greatest importance when making the decision to use FLOSS in the collaborative organization, there is the possibility of participating and taking benefit from the FLOSS community. A source of motivation for a company of a collaborative nature may be the fact of implementing software that enjoys the same philosophy. For moral, marketing, or other reasons, these types of companies are especially motivated to be part of this pioneer community in the collaborative field. On the other hand, regarding the cost saving factor, it has been valued as a factor with intermediate importance, obtaining a score of 5. This shows again how the use of FLOSS does not necessarily imply free software, even if it is a factor to consider.

Also, it should be noted that all the factors are considered when using FLOSS by collaborative organizations, obtaining in all of them an agreed valuation of 4 or higher. Therefore, with the results obtained, it can be concluded that there are no totally decisive factors when implementing FLOSS, but that it is a set of aspects, with similar importance, that lead collaborative organizations to implement the FLOSS.

As for the impeding factors, the most relevant one is the resistance to change. At first, we might think that, in the field of CE, because it is a purely innovative and transformative segment of the economy, it does not fear changes. However, experts have reached the consensus that resistance to change is a factor that could be a major brake in the implementation of FLOSS in the collaborative field. This reflects the importance that today the proprietary code within overall economy still has, including the collaborative one.

This factor is followed, with 5, of insufficient skills, lack of strategic plan, management or support, lack of quality information or information at all, incompatibility with legacy systems and the effects of trends, valuing the rest of the factors with 4. As with the motivational aspects, in this case there are no essential obstacles for the use of FLOSS, considering a wide variety of factors that can influence when deciding whether to use collaborative software or not.

4.3. FLOSS use typology in the CE components

This section, not being quantitative, but based on multiple-choice questions, does not follow the same consensus criteria per interpolated median as the other sections, but rather the number of experts who have marked each option. The section is divided by collaborative components and by internal use or distribution of FLOSS. It should be pointed out that, in view of the results obtained, the type of use given to FLOSS in the different components seems to be quite similar. The results, which show the frequency of responses in the second round, are reflected in Table 4.

First, regarding the internal use of FLOSS, most experts considered that for the component of collaborative consumption, it is mainly used in databases, tools that allow the development of the source code and the source code of the digital platform itself, as it has been shown in their answers, which are as follows 87%, 80% and 73%, respectively. Second, 93% of the experts believe that this component partially distributes the source code, while 67% consider that it is distributed in its entirety. This reflects the expert́s opinion, that there are many collaborative consumption platforms that distribute their source code entirely, although most of these platforms do so partially.

For the component of collaborative production, the most used type of internal employment is repeated, since 80% of experts have marked in databases, tools that allow the development of the source code and the platform's own source code. 80% of experts believe that the source code is partially distributed and 67% is fully distributed. Similarly, in open knowledge platforms, experts once again believe that FLOSS is mainly used in databases, tools that allow the development of the source code and the platform's own source code, as seen in the corresponding results, which are 80%, 80% and 73%. In this component 87% of the experts consider that the source code is partially distributed, and 60% believe that is totally distributed.

Nevertheless, analyzing the results in the component of collaborative finance, the expert́s opinion changes. There is a total consensus that FLOSS is used for tools that allow the development of the source code. In addition, 67% of experts believe that they are also used in the database

Table 3
Results in the first round.

Item	Description	Mean	Standard Deviation	Median	N° responses	Interquartile ratio*
1.1.1	Collaborative consumption	52.7	1.91	60	8	53.3%
1.1.2	Collaborative production	75.3	1.13	70	8	53.3%
1.1.3	Collaborative knowledge	80.7	1.53	90	10	66.7%
1.1.4	Collaborative finance	50.7	1.71	60	10	66.7%
1.1.5	Open governance	55.3	2.03	60	12	80.0%
1.1.6	Value co-creation	62.7	2.46	70	7	46.7%
1.2.1	Banking, insurance, and consultancy	38.7	1.81	40	9	60.0%
1.2.2	Health	42.7	1.67	40	9	60.0%
1.2.3	Transport and logistics	47.3	2.15	50	10	66.7%
1.2.4	Tourism and leisure	45.3	2.61	40	11	73.3%
1.2.5	Energy	47.3	1.79	40	9	60.0%
1.2.6	Real estate and construction	39.3	1.71	40	6	40.0%
1.2.7	Manufacturing	42.7	2.19	40	12	80.0%
1.2.8	Food and agriculture	45.3	1.85	50	10	66.7%
1.2.9	Education	73.3	1.76	80	11	73.3%
2.1.1	Cultural change oriented to accept FLOSS	5.47	0.92	5	11	73.3%
2.1.2	Perceive FLOSS as quality software	5.53	0.92	6	11	73.3%
2.1.3	Possibility to participate from the FLOSS community	5.33	1.29	6	9	60.0%
2.1.4	Trust in the FLOSS community	5.13	1.06	5	13	86.7%
2.1.5	Interest of end users	5.13	1.19	5	12	80.0%
2.1.6	The end users are programmers	5.13	1.46	6	11	73.3%
2.1.7	Promotion and support of management	4.73	1.44	4	11	73.3%
2.1.8	Perception of savings in acquisition and adoption costs	5.2	1.08	5	13	86.7%
2.1.9	Reduced user dependence on the software provider	4.73	1.44	5	9	60.0%
2.1.10	Consider FLOSS a competitive advantage	5	1.51	5	10	66.7%
2.1.11	Greater funding for FLOSS projects	4.73	1.16	5	11	73.3%
2.1.12	Information on requirements for FLOSS implementations	4.2	1.42	4	11	73.3%
2.1.13	Possibility of adapting the FLOSS software	5.4	1.24	6	10	66.7%
2.1.14	Greater ease in detecting security irregularities	4.6	1.3	5	12	80.0%
2.1.15	Compatibility of FLOSS with other software	4.67	1.23	5	8	53.3%
2.1.16	FLOSS compatibility with hardware	4.8	1.47	5	9	60.0%
2.2.1	Resistance to change	5.8	0.86	6	11	73.3%
2.2.2	Insufficient skills or experience	5.27	0.8	5	12	80.0%
2.2.3	Lack of strategic. management or support plans	5.27	1.16	5	12	80.0%
2.2.4	Existence of infrastructure problems	3.87	1.13	4	13	86.7%
2.2.5	Lack of resources	3.73	1.28	4	9	60.0%
2.2.6	Insufficient legal system	3.67	1.45	3	11	73.3%
2.2.7	Uncertainty or lack of information	4.87	1.25	5	13	86.7%
2.2.8	Lack of relevant and quality information	4.53	1.51	5	11	73.3%
2.2.9	Security issues associated to source code accessibility	3.33	1.5	3	10	66.7%
2.2.10	Insufficient source code quality	3.53	1.36	3	8	53.3%
2.2.11	Incompatibility with legacy systems	5	0.85	5	8	53.3%
2.2.12	High failure rate	3.87	0.99	4	11	73.3%
2.2.13	System complexity	4	1.2	4	7	46.7%
2.2.14	Training costs	3.93	1.1	4	7	46.7%
2.2.15	The effects of trends	4.2	1.21	5	10	66.7%
2.2.16	Problems with suppliers	4.2	1.37	4	9	60.0%
2.2.17	Lack of market acceptance	4.73	1.16	5	14	93.3%
4.1.1	Collaborative consumption	61.3	1.55	60	10	66.7%
4.1.2	Collaborative production	81.3	1.13	80	12	80.0%
4.1.3	Collaborative knowledge	84.7	1.19	90	12	80.0%
4.1.4	Collaborative finance	60.7	1.62	60	10	66.7%
4.1.5	Open governance	68.7	2.03	70	10	66.7%
4.1.6	Value co-creation	62.7	2.09	70	7	46.7%
4.2.1	Banking. insurance and consultancy	51.3	2	60	9	60.0%
4.2.2	Health	57.3	1.94	60	7	46.7%
4.2.3	Transport and logistics	54.7	2.42	60	9	60.0%
4.2.4	Tourism and leisure	60.7	2.66	60	7	46.7%
4.2.5	Energy	51.3	2.17	60	9	60.0%
4.2.6	Real estate and construction	56.7	2.02	60	10	66.7%
4.2.7	Manufacturing	58	2.27	60	9	60.0%
4.2.8	Food and agriculture	58.7	2.13	60	7	46.7%
4.2.9	Education	79.3	1.58	80	10	66.7%

Note: Interquartile ratio=(Number of responses within the interquartile range/Total number of experts)*100

and in the platform's own source code. In relation to distribution there is also an absolute consensus that the source code is partially distributed, 40% of the experts considered that there is total distribution in this component as well.

In the open governance component, all experts agree that FLOSS is used for tools that allow the development of the source code, followed by its use in databases. Besides that, 87% of the experts consider that the code is partially distributed while 60% consider that there is a total distribution.

Finally, in the systems of exchange of value the same dynamic is repeated, having been marked the use of FLOSS in database, tools that allow the development of the source code and in the source code of the digital platform, by the 73%, 87% and 60% of experts. 80% of the experts consider that the code is partially distributed while 47% consider that there is a total distribution. Therefore, it should be noted that the type of application of FLOSS is very similar in all collaborative

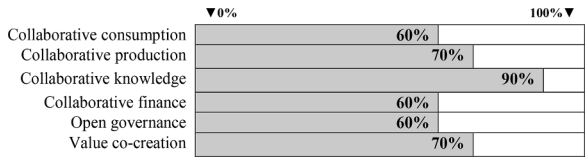

Fig. 1. Current implementation scenario of FLOSS by CE components. Second Round.

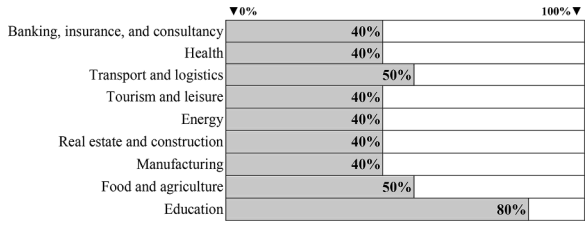

Fig. 2. Current implementation scenario of FLOSS by industries. Second Round.

platforms, coinciding with a high number of experts in that this type of organizations share their source code, partially on some occasions, but sometimes also totally.

4.4. FLOSS Implementation in 2025 of in the CE components by industries

The results obtained in the forecasting questions are presented in this section. Through these results, the expected trajectory of the level of FLOSS implementation in the CE components by industry for the year 2025 is revealed. The results agreed in the second round are reflected in Figs. 5 and 6, which should be compared with the current situation that the experts have presented in the Section 4.1.

In general, comparing this scenario with the current, the experts have defined a very similar scenario, identifying small upward variations. On the one hand, by 2025, the experts estimate that the scenario will be the same, except for collaborative production and open governance. Both components of the CE would reach 10% more of FLOSS implementations. Moreover, the greatest implementation of FLOSS will be in collaborative knowledge and production, with 90% and 80%, respectively. These are followed by open governance and co-creation systems with an implementation of 70%, and, finally, consumption and collaborative finance with a 60%. We can affirm that these results are in line with previous studies. As it was described in the Section 2.1.4, the importance of collaborative knowledge in the economy has been highlighted by many authors (Archer-Brown and Kietzmann, 2018; Morell, Salcedo and Berlinguer, 2016; Pedersen, 2015), due to open knowledge represents the foundations of the CE. In a similar way, as it was expected, the level of implementation in 2025 for the collaborative production has been high. In this respect, collaborative production allows companies to adapt to a way of networking in an increasingly globalized world (Ko and Nof, 2012; Levalle, Scavardab and Nof, 2013). In fact, we have found in the collaborative production the closest connection between FLOSS and CE.

On the other hand, regarding the level of implementation of FLOSS, considering the studied industries, the scenario defined by the experts for the year 2025 significantly improves the current values. In this line, a general increase of between 10% and 20% is expected in all industries, excluding the education industry, where it is observed an increase of 30%. These results reveal that all industries consider that FLOSS could be relevant in the development of their activities and that, therefore, FLOSS could be considered as a viable alternative to other types of software, such as proprietary software. This is the case of the education industry, where several studies have indicated that FLOSS has an important presence in the development of educational activities (Racero et al., 2020; Gallego et al., 2015). That is why experts have assigned a high percentage of implantations to this industry.

5. Conclusions

The application of the Delphi method has allowed to draw relevant conclusions about the current and expected level of implementation of FLOSS in the companies and organizations that make up the CE by the year 2025. In addition, with the results obtained, it has been possible to identify the factors that, within the CE, motivate and hinder its implementation, as well as the type of application that is given. Therefore, the methodology used has allowed to cover the objectives set after having agreed on a current and forecasting scenario by a heterogeneous panel of experts in the field. The rigour of the results obtained should be highlighted thanks to the collaboration of highly recognized experts in the field of the study.

In this sense, a significant role of FLOSS in the CE is revealed. Concretely, the component of collaborative knowledge heads the growth of FLOSS implementation in the CE. In this manner, experts forecast a

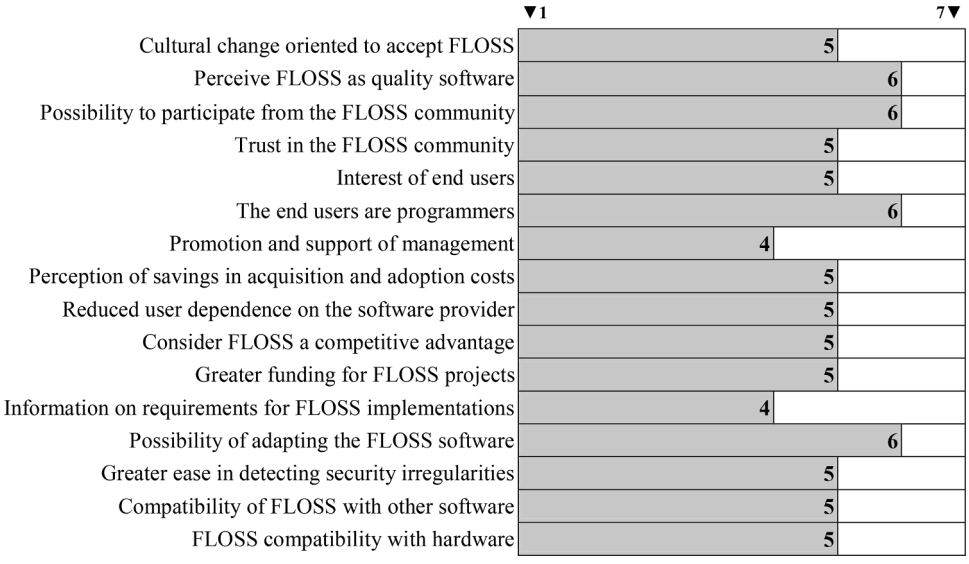

Fig. 3. FLOSS motivational factors in CE organizations. Second Round.

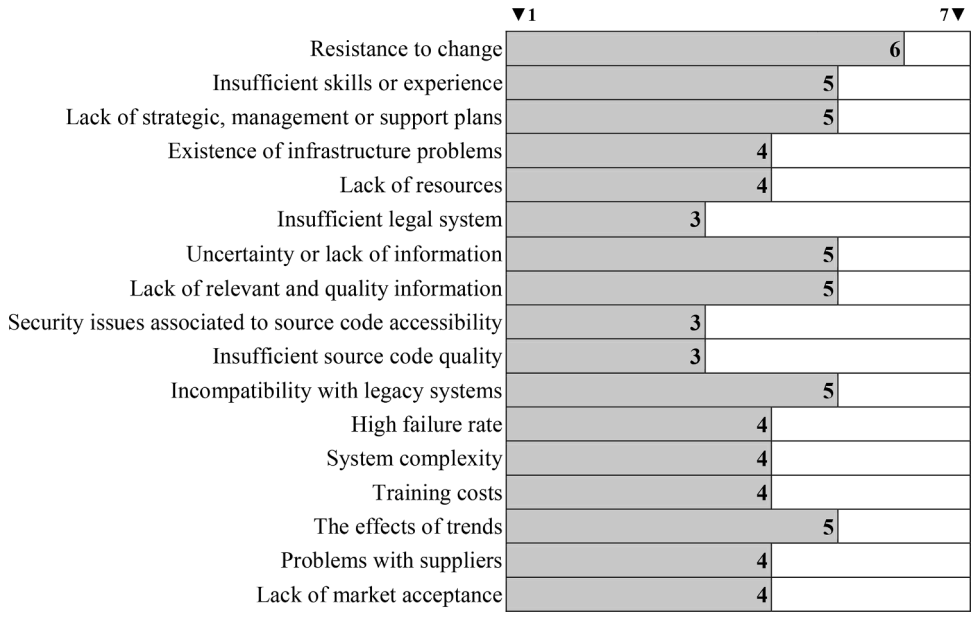

Fig. 4. FLOSS obstacles in CE organizations. Second Round.

Table 4
Internal use and distribution of FLOSS by CE components. Second Round.

	Consumption	Production	Knowledge	Finance	Governance	Value Co-creation
Internal use and distribution of FLOSS						
1	73%	80%	73%	67%	53%	60%
2	80%	80%	80%	100%	100%	87%
3	27%	7%	40%	20%	20%	13%
4	87%	80%	80%	67%	67%	73%
5	27%	47%	20%	27%	27%	40%
6	74%	47%	47%	27%	27%	13%
7	-	-	-	-	-	-
FLOSS Distribution						
8	67%	67%	60%	40%	60%	47%
9	93%	80%	87%	100%	87%	80%
10	13%	7%	27%	-	-	7%
11	-	7%	-	-	-	-
Codes:						
Internal use of FLOSS		**FLOSS Distribution**				
(1) FLOSS use in the source code of the collaborative platform		(8) Distribution of the entire source code under FLOSS license				
(2) Source Code Development Tools		(9) Partial distribution of the source code under FLOSS license				
(3) Management and administration systems		(10) Tools distribution outside the main activity under FLOSS license				
(4) Database		(11) No type of distribution				
(5) Project management software						
(6) Office tools						
(7) None						

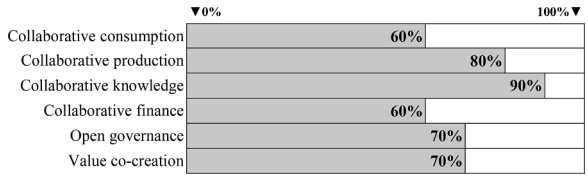

Fig. 5. FLOSS implementation scenario in 2025 by CE components.

stable scenario, estimating that the levels of FLOSS use in the CE will practically be maintained, with a 10% increase by 2025 in the production and open governance component, and between 10% and 20% in all industries except for education, where its current level will be maintained, being this the highest.

Based on the results achieved, the agents that make up the CE are recommended to implement FLOSS in their organizations, since quality, flexibility, and being part of the FLOSS community are, among others, factors that can report benefits, having been considered by numerous collaborative organizations that use and will maintain the use of collaborative software in the coming years.

These results allow defining some practical implications, possible strategies, recommendations, and and potential risks for the analyzed industries. Thus, the findings show that manufacturing could be one of the industries most benefited from applying FLOSS in a collaborative environment. FLOSS has the potential share in an effective and efficient manner production resources based on collaborative resource sharing system if barriers associated with problems with suppliers are overcome. This aspect could lead to improve the customer satisfaction since products can incorporate customer requirements in a more agile manner when they are developed in a collaborative way. Similarly, the real estate and construction could acquire similar advantages to the manufacturing industry. In this manner, companies from this industry that make FLOSS their business model, could obtain some benefits from

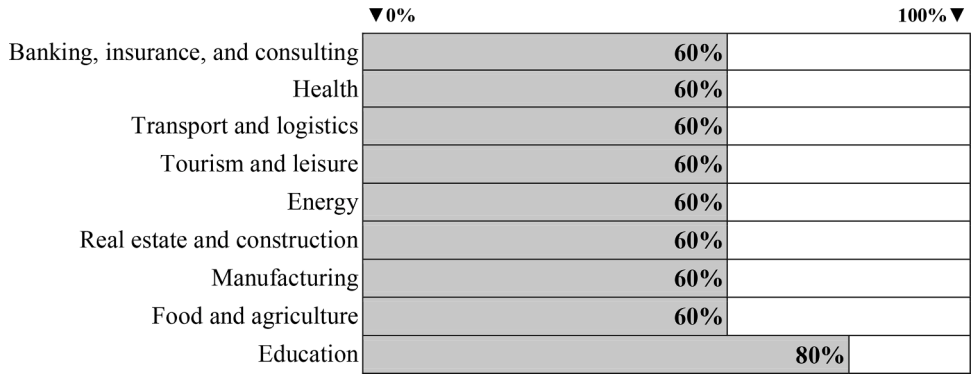

Fig. 6. FLOSS implementation scenario in 2025 with CE proposes by industries.

operating in collaborative contexts, such as, better adjustment between customer needs and requirements with the offer, lower costs, or an enhancement of home customization. To achieve these benefits, it may be positive to overcome barriers such as insufficient skills or experience or he effects of trends.

Moreover, the banking, insurance, and consulting industry could be one of the most affected by the CE in the forthcoming years. In fact, companies of this industry can offer new ways of financing and investment outside the traditional financial offer, such as, (1) crowd funding, (2) peer-to-peer lending, and (3) currency exchange. Besides, FLOSS could boost these new manners to allow to connect individuals with financing or insurance needs. In this line, we recommend using FLOSS in the CE to reduce barriers to accessing financing. However, the customer resistance to change or an insufficient legal framework could be two important obstacles in the development of this field.

In addition, the health industry could achieve advantages from FLOSS in collaborative environments. We refer to the capacity of FLOSS of allowing the cooperation between the different stakeholders in the health industry to design specialized software tools. This type of software could improve the organization of medical needs in regions or connect all agents in the health industry to plan strategies. These same implications could be extrapolated to the energy industry. Thus, similarly, the energy industry could lean on FLOSS to design new models for the renewable transition, which is widely related to collaborative contexts. In this manner, perhaps some of the main risks for the diffusion of FLOSS in both industries in collaborative environments are the existence of infrastructure problems and the lack of strategic, management or support plans.

Also, the collaborative consumption is extensively spread in industries such as transport, food, and tourism. In fact, frequently many investigations have analyzed cases from these industries as examples of collaborative consumption (Huber, 2017; Casprini, Di Minin, and Paraboschi, 2019; Abbes, Hallem and Taga, 2020). In these contexts, FLOSS could be useful to companies from these industries for the definition of new collaboration oriented-open systems to analysis the market evolution. These systems would allow to provide quick responses to new consumer needs, although a possible barrier that would hinder its spreading would be the lack of market acceptance.

Additionally, we believe that the education industry provides renovated environments that enhances collaborative knowledge. In fact, FLOSS is an essential element of the collaborative knowledge due to it is based on open knowledge. In this manner, the importance of FLOSS in the education has been widely analysed. In this line, open knowledge represents a crucial foundation of the education. Considering these aspects, students could benefit from higher quality education by reducing barriers to access to knowledge. In addition, FLOSS allows to design software that facilitate the learning and assimilation of knowledge.

It turns out necessary to highlight some limitations present in the study. This research has required specialized knowledge in very diverse industries, which has made it difficult to find experts with a comprehensive knowledge of the subject matter. It has been tried to replace this limitation with the intervention of experts belonging to each of the components of the CE, experts in FLOSS and eminences of the CE in general. For this reason, the study would have enjoyed greater robustness with a wider panel of experts, although the size of the panel is within the recommended range.

Finally, regarding future research, it is worth pointing out the following, concerning the distribution of FLOSS in the CE. The experts, in all the collaborative components consider that the source code is distributed both partially and totally, but for reasons of research fluency, it has not been possible to go into greater detail. In this way, it is unknown whether these organizations share the source code of essential programs for their activity, or only those secondary ones. This is an extremely interesting aspect to investigate, as it would reveal to what extent collaborative organizations wish to be collaborative at the level of technological policy.

Author statement

Eloísa Menéndez-Caravaca: Formal analysis; Funding acquisition; Investigation; Methodology; Roles/Writing - original draft

Salvador Bueno: Formal analysis; Funding acquisition; Roles/Writing - original draft

M. Dolores Gallego: Formal analysis; Methodology.

CRediT authorship contribution statement

Eloísa Menéndez-Caravaca: Conceptualization, Data curation, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – review & editing. **Salvador Bueno:** Conceptualization, Data curation, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – review & editing. **M. Dolores Gallego:** Data curation, Formal analysis, Methodology, Supervision, Validation, Writing – review & editing.

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