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Facing Obsolescence: Component Repair and Collaboration in the Independent ICT Commercial Repair Sector

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Correspondence: Francisco López-Bermúdez (franciscolopez.bermudez@usc.gal)**Received:** 27 August 2025 | **Revised:** 10 February 2026 | **Accepted:** 24 February 2026**Keywords:** circular economy | ecodesign | obsolescence | planned obsolescence | repair | repair policy

ABSTRACT

Repairs are becoming more difficult to perform due to multiple factors, including obsolescence, complexity of designs, technological change and lack of information and spare parts. This underlines a conflict between repair and technological designs driven by accumulation logics that require increasing growth rates. Despite these challenges, independent repairers persist. This exploratory research addressed how repairers working with ICT equipment actively circumvent obstacles and barriers using technical and collaborative arrangements that have often been overlooked in most commercial repair analysis. This paper uses insights from a survey sent to independent commercial repairers in the region of Galicia (NUTS ES11). Insights show that repairers employ repair techniques, such as component repair, to avoid manufacturers' control while also using collaborative networks for information exchange, skill sharing and commercial cooperation. This reveals that the repair sector is more complex than previously assumed and more similar to other knowledge-intensive industries. Current repair policy insufficiently supports independent repairers and the tools they rely on. Ecodesign provisions so far have neglected component repair and the need for improved information and know-how transfer.

1 | Introduction

Interest in repair has been rising steadily in the Global North due to its role as a core activity in the circular economy paradigm (Stahel 2013; Gharfalkar et al. 2016; Ellen MacArthur Foundation 2015; Blomsma and Tennant 2020; Vence 2023). This seemingly inconspicuous practice has proven to be a source of inspiration for academics since Graham and Thrift (2007) began the 'resurrection of the activities of repair and maintenance in the social sciences', which meant acknowledging the key role of repair in economic systems and infrastructures. Repair was noted as a special activity in that it conjured creativity to overcome decay and breakdown, and it has been identified as a form of care for the material world (Jackson 2014, 2019; Houston and Jackson 2016; Cohn 2017; Forlano 2017; Denis and Pontille 2017). Repair evolved alongside our own material cultures (Packard 1960; Krebs and Hoppenheit 2022), and recently it became not only a commercial practice but also an

activist initiative performed around the globe and closely tied to notions of sustainability, sovereignty, and resilience (Cole and Gnanapragasam 2017; Charter and Keiller 2014; Charter and Keiller 2016).

In the context of Electric and Electronic Repair and more specifically ICT repair, it is seen as a potentially more sustainable alternative to manufacturing. The outcome of a successful repair is a useful and functional device, which means that repair can potentially reduce the need to produce a new one. Consequently, it could reduce environmental impacts by slowing down production and waste. From a metabolic point of view, repair keeps value intact, value understood as order imbued to matter (Baumgärtner 1996; Costanza et al. 1997), and it reduces the influx of matter entering the stock (raw materials) and leaving it (waste), making it an essential tool to manage societal stocks more sustainably (Victor 2008; Daly 1996; Vence 2023). Beyond its environmental potential, repair can

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also contribute to reducing geopolitical dependence by reducing the need for critical materials, which for Europe come mostly from abroad (European Commission 2018). Simultaneously, the existing stock of critical materials is being sent abroad as part of export waste streams (Llorente-González 2024). This leaves the European economy in a precarious situation. By keeping resources intact as part of the goods they are integrated in, repair cannot only reduce environmental impacts derived from manufacturing and waste, but also reduce international dependence on critical resources and contribute to sustain existing infrastructures more effectively.

In addition to its potential for sustainability and resilience, repair has a high labour creation potential, first due to it being highly labour-intensive, second due to it being highly distributed territorially (Llorente-González and Vence 2020; López-Bermúdez and Vence 2023; Vence and López Pérez 2022a). This makes repair an attractive alternative to the linear economy, as it is largely a mature and consolidated activity already embedded in the consumption patterns of most households. The realisation of the potential of repair and the growing academic interest has materialised into specific legislation promoting repair in the European Union. Two key legislative pieces have been recently passed: the Directive on common rules promoting the repair of goods (2024/1789) and the Regulation for sustainable design of products (2024/1799). Even though the transformative potential of these legislative measures turned out to be underwhelming (López-Bermúdez and Vence 2024, 2025; Puentes 2024), it is more necessary than ever to develop a sounder understanding of repair and the obstacles repairers face.

The current accumulation pattern and the production-consumption system rely on constantly expanding markets. Durability and reuse (repair) can potentially slow down consumption, which poses a threat to the current growth-dependent established order (Vence 2023; Vence et al. 2024). This materialises into an economic system that is not conceived to be restorative and that exhibits structural barriers to repair. Despite this, repair of ICT equipment remains a valid and consolidated economic practice, which raises the research question: What repair practices do independent commercial repairers employ to work around barriers to repair?

This paper draws upon existing literature on barriers to repair and current repair practices (cf. López-Bermúdez and Vence 2025; Türkeli et al. 2019; Dalhammar et al. 2020; Richter and Dalhammar 2019; Riisgard et al. 2016; van der Velden 2021; van der Velden et al. 2024) to explore the actual practices used by independent commercial ICT repairers to overcome barriers and remain relevant agents in the repair market. This research focuses on commercial independent repairers which operate in the market, often as small or microenterprises. To answer the research question, this study compiled data from questionnaires sent to ICT independent repairers working in Galicia (ES11 NUTS region). This paper focuses on two dimensions in particular: collaboration and repair techniques. Collaboration has been widely acknowledged in community repair contexts (Cole and Gnanapragasam 2017; Jorgensen 2024; Parajuly et al. 2024) but seldom in commercial ones (cf. Orr 1996; van der Velden et al. 2024). Techniques of repair, on the other hand, involve the usage of component and module repair. Modules are functional

units inside objects (e.g., screens, batteries, processors...) while components are parts within modules whose purpose is to allow the module to perform its intended function (e.g., capacitors, connectors...). Both repair approaches have distinct implications and difficulties and offer distinct advantages.

The structure of this paper is as follows: Section 2 covers the literature review, where structural barriers to repair are presented. Section 3 contains the methodology, which involves the data collection and analysis techniques. Section 4 presents the results. In Section 5 the main findings are discussed in relation to the existing evidence regarding barriers to repair and the relevance for repair policy. Finally, Section 6 contains the conclusions.

2 | Literature Review

2.1 | Barriers to Repair

Barriers to repair are a key element in repair research, given that the current economic system is not designed to be restorative (Laitala et al. 2021; Parajuly et al. 2024; de Fusco 2005; Fry 2009). Barriers, in the context of this research, refer to structural and systemic obstacles that make repair of ICT equipment more difficult, more expensive, less attractive, less feasible, or even impossible. Barriers to repair can be divided into two main categories: access barriers to repair and competitive barriers to repair (Svensson et al. 2018), which in turn can be subdivided into more specific barriers. Access barriers to repair tend to impede repair even when desired by the user. Competitive barriers to repair tend to make it less feasible or attractive. The different barriers may affect consumers, repairers, or both and in varying degrees.

Table 1 summarises the main barriers identified in ICT repair, alongside specific references. Regarding the classification of barriers, it is important to bear in mind that classifications and categorisations are useful for analytical and scientific purposes, since they allow researchers to share and consolidate knowledge and help make sense of complex realities. Multiple categorisations can be employed, depending on the aim of the analysis. For this paper, a rather holistic approach to the barriers was adopted.

Mapping barriers to repair can help identify and characterise the ways in which repairers work, often having to work against or around them.

2.2 | Repairers Against Obsolescence

The current mode of production-consumption, which is bent on incentivising growth through new production, is generally unfavourable to repair practices, as seen by the barriers to repair ingrained in the system's architecture (cf. Svensson-Hoglund et al. 2021; López-Bermúdez and Vence 2025). As a result, repairers that work with ICT societal stocks have to deal with constantly decaying systems and infrastructures, which is an intrinsic condition of materials due to entropy (Daly 2007), while having to face structural barriers that stem from a market architecture controlled by corporations that prioritise growth through sales.

TABLE 1 | Access and competitive barriers to ICT repair alongside specific sources.

Categories	Barriers	Description	Sources
Access barriers to repair	Legal obstacles	Arguably the main access barrier. It involves Intellectual Property (IP), guarantees or extended producer responsibility	see, Dalhammar et al. (2020); Svensson et al. (2018); Svensson-Hoglund et al. (2021); Cole et al. (2018); Nogueira (2024)
	Access to parts	Often tied to legal obstacles (particularly IP). Absence of the necessary parts can prevent repair altogether	see, Cole and Gnanapragasam (2017); Korsunova et al. (2023)
	Access to information	As with parts, often tied to legal obstacles (particularly IP). Absence of the necessary information can prevent repair altogether	see, Riisgard et al. (2016); Grinvald and Tur-Sinai (2019); Türkeli et al. (2019)
Competitive barriers to repair	Relative prices	Price of a repair relative to the price of a new good, both dichotomous alternatives.	see, Jorgensen (2024); Güsser-Fachbach et al. (2023) Deloitte (2018); European Commission (2023); Lefebvre et al. (2018); Wieser and Tröger (2017); McCollough (2009); Vence and López Pérez (2022b)
	Obsolescence	Obsolescence is a complex phenomenon involving material, functional and psychological considerations. It is influenced by technological changes, design and individual and social preferences	see, Packard (1960); Öko-Institut e.V. (2020); Cooper (2004 & 2010) Svensson-Hoglund et al. (2023); Proske et al. (2016); Walker (2006)
	Convenience and trust	Often associated with consumers' distrust of professional repairs and often influenced by the consumers' own lack of knowledge about their devices	see, Cole and Gnanapragasam (2017); Ackermann et al. (2018); Andersson et al. (2018)

Note: Own elaboration based on Vence et al. (2024); López-Bermúdez and Vence (2024, 2025) and Svensson et al. (2018).

In previous studies collaboration has been noted as a tool for developing repairers' capabilities and thus create human capital, which in this case involves information sharing as well as know-how exchange. Orr (1996) noted that repairers rely on each others' experiences, which are usually casually shared, to learn and develop the appropriate know-how. Community repairers, as its name denotes, rely on knowledge and experience accessed through cooperative arrangements (van der Velden 2021; Houston and Jackson 2016; Charter and Keiller 2014, 2016). Also, beyond capacity building, collaboration between stakeholders and particularly with local authorities has been noted as crucial for the success of repair initiatives, be those community or commercial ones (Moalem and Schmidt 2023; van der Velden 2021; Güsser-Fachbach et al. 2023; Jorgensen 2024).

Beyond collaboration, repairers have been found to employ varied technical strategies to address barriers and obstacles. Jackson (2014) noted that repairers often employ Broken World Thinking to overcome barriers and find innovative ways to perform repairs. In the context of the developing world, repairers often have to face barriers conceived for a completely different socioeconomic context (Jackson et al. 2012; Houston and Jackson 2016). In the context of technology development, Cohn (2017) noted that repair was key to the operations stage,

meaning that the moment a technology is placed on the world it encounters problems and starts to fail, making repairs necessary, often in the form of physical solutions or transformations.

Through interviews and direct contact with repairers, two distinct forms of performing repairs were identified: component repair and module repair. Modules are distinct parts of the product. They serve a specific function and perform certain tasks (e.g., screen, graphic card or processor). Components, on the other hand, are smaller elements within the modules. Their role is to allow the modules and by extension the product itself to work as intended (e.g., individual circuits, boards, capacitors...). Figure 1 illustrates graphically the role of parts and components within devices.

Module repair involves replacing faulty parts with other ones in working order (which may be brand new or reused), whereas component repair involves repairing the parts themselves or replacing individual components within the parts in order to restore the device without the need to replace any parts. In repair and Right to Repair literature emphasis has been placed on parts (modules) and their availability, which are indeed crucial to allow repair (cf. Laitala et al. 2021; Korsunova et al. 2023). However, the role of components has largely been overlooked.

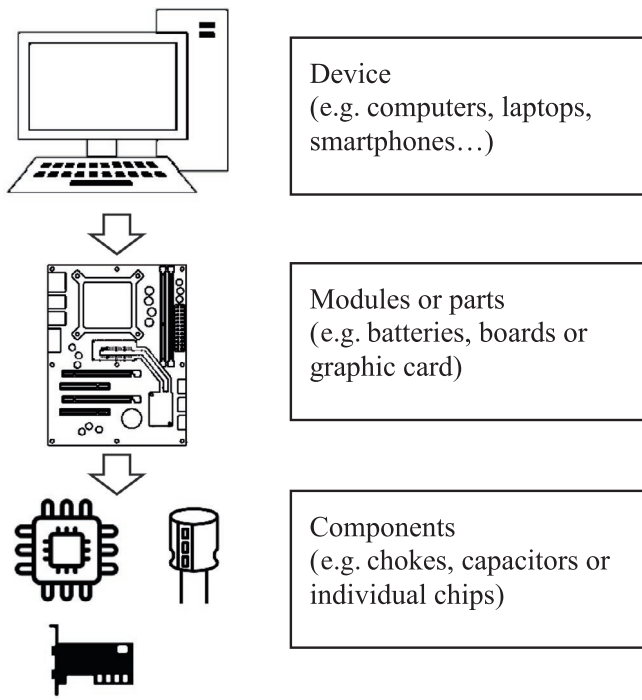


FIGURE 1 | Graphic representation of parts and components in devices. *Source:* Own elaboration.

This research aims to develop a sounder understanding of the repair process of ICT goods by exploring the approaches that independent repairers use regarding component and module repair; as well as the extent to which collaboration is used in commercial repair contexts.

3 | Methodology

To fulfil this research objective, an original database was compiled using surveys from commercial independent ICT repairers. As mentioned in the introduction, the repair environment contains community and commercial repair initiatives. In commercial repair we identify two main groups: official or associated repairers that work for manufacturers and independent repairers, which tend to operate in the free market. The questionnaire was informed by a review of previous questionnaires conducted with both community and commercial repairers (Charter and Keiller 2014; Charter and Keiller 2016; Graziano and Trogal 2017; Graziano and Trogal 2019; Dalhammar et al. 2020; Türkeli et al. 2019; Andersson et al. 2018; Riisgard et al. 2016); as well as by a series of semi-structured interviews conducted with repairers working with high technology equipment. These interviews helped identify the agency of repairers in overcoming barriers to repair. The interview guide can be seen in the Annex. Common procedures and practices were followed for the interviews and its analysis (Souza-Minayo 2017).

3.1 | Data Collection

After beta-testing the questionnaire, it was sent via Google Forms to professional repairers located in the region of Galicia

(ES11 under NUTS classification). A total of 291 invitations to participate in the survey were sent to commercial independent repairers, out of which 60 were completed. This means a response rate of 20.6%, which is common in surveys sent to businesses that are often busy and do not prioritise answering surveys. Selection of potential participants took place online. Contact information was compiled from a regional business site called ‘Páxinas Galegas’ under the category of ‘ICT maintenance and computer repair’.

The questionnaire, which involved multiple choice, dichotomic and short answer questions, had a very decent completion level. Most respondents answered all questions, even offering additional information through short answers when given the opportunity. Table 2 shows completion rates were between 98.3% and 100% for dichotomic and multiple choice questions, and between 50% and 70% for short answers (in this case we have to bear in mind that short answers made reference to previous questions; for instance, the types of collaboration networks was only relevant to those who had confirmed that they took part in collaboration networks, so taking that into account the level of completion is high). The sample was taken from a fundamentally homogeneous population (ICT independent repairers), in which 100% of respondents work with computers and laptops, 73% printers and 70% with mobile phones. Consequently, despite a small sample size (Sauro and Lewis 2016), we consider it relevant for exploratory analysis centred around ICT equipment.

3.2 | Data Analysis

Data collected in this study aimed at exploring some key themes in repair research, most notably perceived repair difficulty, attitude towards component repair and attitude towards collaboration networks. The questionnaire included generic questions about size, age, location and business plan (including whether they sell second hand goods). The complete list of questions used in this research can be seen in Table 2.

Data analysis included the graphical representation of some of the main results regarding attitude towards repair, repair difficulty and collaboration. Graphs and tables were used to represent the attitude of repairers towards component repair and the characteristics of the collaboration networks in which they participate. In order to extract the most information out of short answer questions, a thematic analysis was conducted using a bottom-up inductive approach, in which recurrent themes were identified in the answers themselves and categories identified from them (Silverman 2021). Short answer questions covered the type of collaboration networks, the type of inquiries that they ask alongside the training background of the repairers.

Beyond the statistical description and graphical representation of the data, which is useful for characterising the sector, a secondary analysis was conducted to assess potential relationships among variables. The aim is to conduct an exploratory correlation analysis, focusing in particular on propensity to engage in component repair, participation in collaboration networks, type of training background, age and size of the repair firms. The variables used were 13 in total, 11 of them binary and 2 of them continuous. Correlation analysis was conducted using the

TABLE 2 | Questions and number of answers proposed to the repairers.

Questions	Type of question	Number of answers
Number of employees	Control	60
Age of the firm	Control	59
Location	Control	57
Gender of the respondent	Control	58
Years of experience in the repair industry	Control	56
What types of products do you repair? (computers; laptops; printers; servers; radios; TVs; mobile phones; fridges/freezers; washers/dryers; dishwashers; small household equipment; others)	Multiple choice	60
Are goods designed to be repaired?	Dichotomic	60
Are repairs becoming more difficult	Dichotomic	60
Do you observe innovations and technological changes that make it harder to repair?	Dichotomic	60
Do you think that repairs require more technical specialisation?	Dichotomic	60
Do you hire based on those needs?	Dichotomic	59
Can you obtain spare parts directly from the OEM	Dichotomic	60
Is there a quality difference between third party and OEM spare parts	Dichotomic	59
Do you repair with used spare parts from discarded equipment	Dichotomic	59
Do you perform component repair? (yes, always; yes, sometimes; yes, but we externalise it; no)	Multiple choice	58
What activities do you externalise?	Short answer	42
Do OEM provide enough information to perform repairs?	Dichotomic	60
Do you use other alternative sources of information?	Dichotomic	60
Do you know other repair businesses in the area?	Dichotomic	60
Do you know someone that works there?	Dichotomic	60
Do you participate in any collaboration network (i.e., direct contact, social media groups, associations...)?	Dichotomic	59
What type of collaboration network?	Short answer	30
What types of inquiries do you usually ask?	Short answer	32
What training did you have in order to work as a repairer?	Short answer	58
		N = 60

Source: Own elaboration from questionnaires.

Pearson index for continuous-continuous and continuous-binary data pairs and the phi-coefficient was used to assess correlation in binary-binary pairs of data (Nguyen 2025). Ultimately, this approach requires a nuanced interpretation of the potential association of variables, which given the nature of the analysis does not imply causality (Betensky 2019). This analysis was conducted using SPSS software.

4 | Results

First, data is presented regarding repairers' attitude and thoughts on obsolescence, component repair, participation in collaboration networks and training backgrounds. Finally, the potential

relationships between variables are addressed, exploring the interconnections among the themes explored in the questionnaire.

Regarding independent repairers' attitude towards obsolescence, several yes or no questions were proposed regarding difficulty, technological change and cooperation with OEMs in terms of spare part and information supply as well as questions regarding collaboration networks. The answers can be seen in Figure 2.

In general, repairers agree that goods are not designed to be repaired and that repairs are becoming more difficult. When inquired about technological change, they point out that more specialisation is required than it used to be. At the same time, respondents agree that there is little engagement with OEM

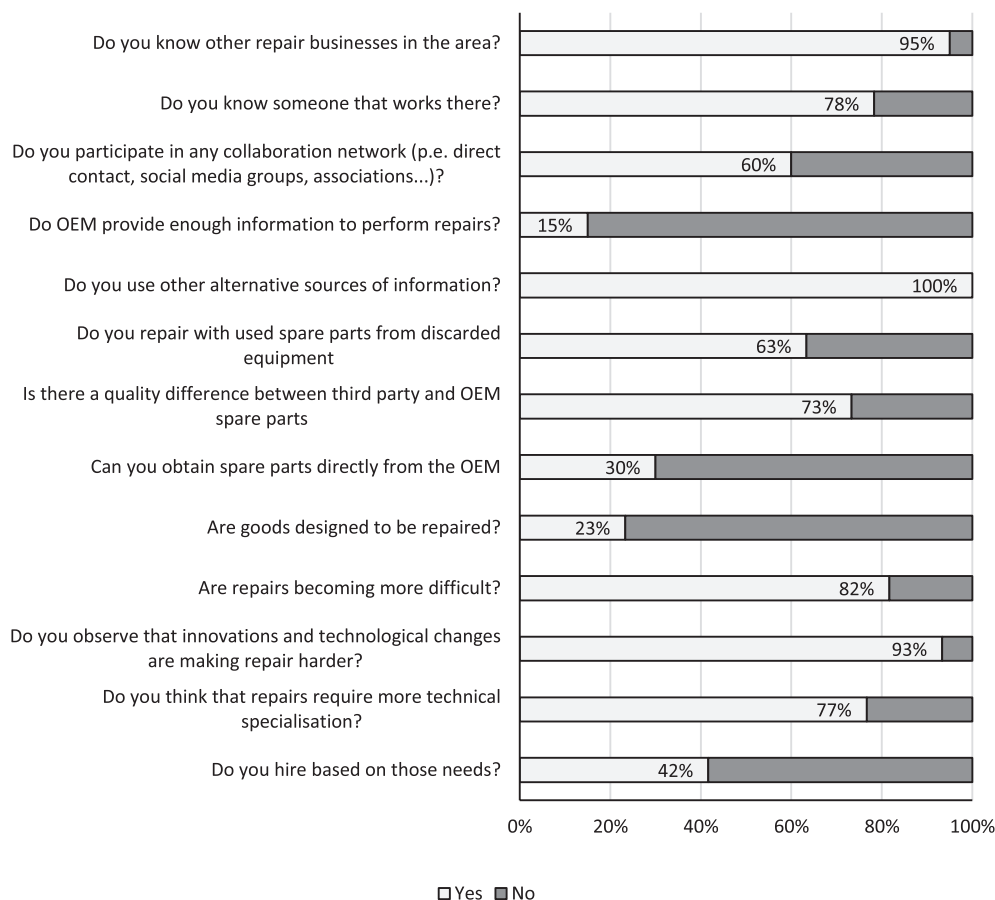


FIGURE 2 | Repairers' perspective on repair difficulty, technological change, spare parts use and information sharing. *Source:* Own elaboration from questionnaires.

(Original Equipment Manufacturers); for instance, a majority of repairers use discarded equipment as sources for parts. A second avenue of approach had to do with knowledge and information. As with the technical aspects of repair, the questionnaire inquired about the difficulty of acquiring knowledge, adding some questions to determine if repairers do participate in collaboration networks. The results can be seen in Figure 2. Most repairers agree that OEMs do not provide enough information to perform a repair, while even those that claim that they do also admit to using alternative sources of information to perform repairs. When inquired about collaboration networks, most repairers noted how they have an awareness of the repair environment in which they are inserted. Up to 78% of respondents admitted that they personally know someone working in another repair firm in the area. When asked specifically about collaboration networks, 58% of respondents noted that they do participate in collaboration networks.

In terms of the techniques of repair, the questionnaire inquired specifically about component repair. During the semi-structured interviews with repairers, two distinct techniques of repair were identified: component repair and module repair. Modules are parts, entire elements that play a specific role inside a device (e.g., boards, graphic cards, batteries, camera assemblies...). Parts are in turn made out of specific components, which allow the part to function as intended. Independent repairers operate at both levels, the module and the component level. Each specific approach has its advantages and its disadvantages. Component

repair is very cheap material-wise, but requires more knowledge and it is more time consuming. Being able to repair without having to use a new spare part removes the manufacturers' ability to control the repair process through the spare parts market. Module repair, on the other hand, is relatively fast and requires less knowledge, yet it is more expensive material wise. The susceptibility of repair at the module level is dependent upon the spare parts' market, which determines availability and price.

During the preliminary interviews with independent repairers, those with most years of experience claimed that component repair is a lost art and that most repairers today operate only at the module level. This pessimistic attitude is seemingly prevalent among independent repairers (cf. van der Velden et al. 2024). However the questionnaires showed that most repairers do in fact still repair at the component level (Figure 3). Fifty-five percent claim to repair either always or sometimes at the component level, 33.3% claim to externalise the service to specialised third parties and only 11.7% claim to never repair at the component level. This denotes that despite obstacles, independent repairers remain competent and skilled in the different repair techniques. When asked about what procedures they externalised the most, repairers mentioned microelectronics and microwelding. Potentially due to design features of current ICT devices.

Besides the repair level, collaboration was another of the core aspects to study. Sixty percent of the participants claimed that they did in fact participate in some form of collaboration network (see

Figure 2 above). To expand upon this, short answer questions were included regarding the type of collaboration network they participated in and the types of inquiries they made. Thirty repairers answered these short questions, which provided enough data for a thematic analysis to be performed. Results can be seen in Figure 4. Note that many repairers participate in more than one type of network and may ask different types of inquiries, hence why N amounts to more than 30.

Thirty-one percent respondents use direct contact measures, either physical visits or phone calls to colleagues. One claims that 'we are in constant contact with various colleagues in the sector' other than that 'we help other shops in the area when they have a problem. We care for one another'. Thirty-six percent participate in local social networks groups. These are local networks, even though most of them take place through online platforms. The local character is indicated in the answers 'we have a Telegram group with around 60 members. Most are from

here'. Twenty-eight percent participate in national and international networks organised through online platforms. In this case, most simply answered with the network used: 'whatsapp' or 'Telegram'. Only 5% of the respondents noted that they took part in formal associations. For instance, 'we are part of a business group' and 'we have a municipal technology association'.

Regarding the types of inquiries, most respondents noted technical aspects as the main topic, 43% on how to perform certain procedures ('type of solutions to certain problems' or 'how did you open this or that device?'), 19% how to obtain the necessary information ('how to interpret error codes') and 9% explicitly mentioned software ('some ask us about smartphone software'). Other inquiries were business related, 14% mentioned stocks ('do you happen to have this spare part?' or 'we exchange spare parts') and 15% mentioned commercial collaborative arrangements ('we derive printers to some colleagues that are dedicated to that' or 'we ask about spare part

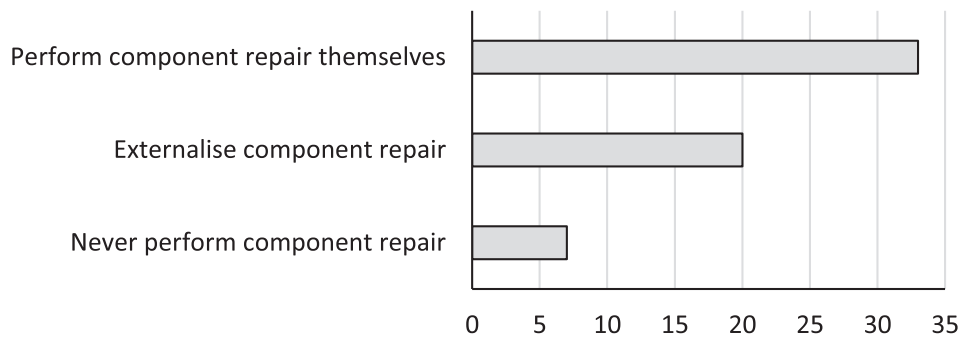


FIGURE 3 | Attitude of repairers towards component repair. *Source:* Own elaboration from questionnaires.

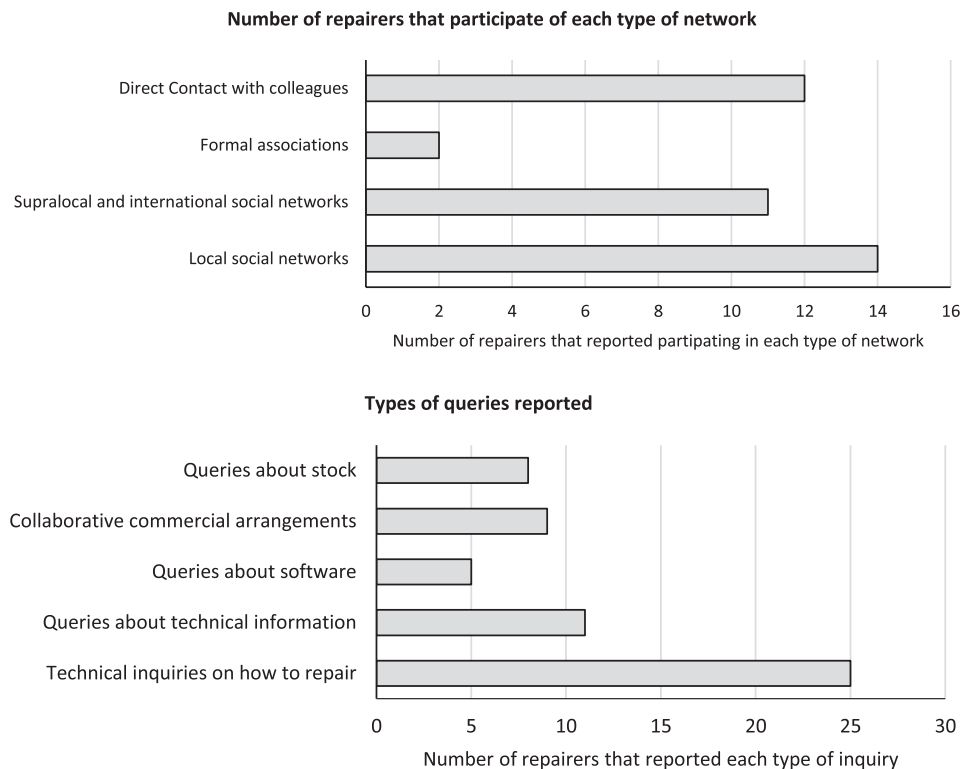


FIGURE 4 | Type of collaboration networks that independent repairers participate in and types of queries they make. *Source:* Own elaboration from questionnaires.

prices and which ones are the best suppliers'). These tend to involve exchanging repairs with colleagues and market information about prices and suppliers. Exchanging repairs with colleagues allows repairers to specialise without having to externalise the procedure to a third party.

In any case, the answers provided were not exhaustive but rather exploratory. Even though the percentages cannot be regarded as precise measurements, they help identify collaborative trends in the repair industry. This analysis shows how complex and deep the relations can be. The details given, even when subtle, indicate an intricate network often formed over the years and through mutual trust.

Another short answer was devoted to inquiring about the training and education of repairers. The results can be seen in Figure 5. As before, the results were obtained using a bottom-up approach to identify the categories (self-taught training, university training, professional training and attendance to specific courses). Note that many participants had more than one type of training, most often professional training and superior studies and specific courses alongside other forms of training. Most respondents showed to have professional training, either basic or superior, followed by those with superior studies and finally self-taught repairers as a dying breed. Eleven respondents claimed to have had multiple courses to specialise in certain forms of repair (for instance, 'I was self taught, but attended multiple courses over more than 30years' or 'training courses offered by the manufacturers').

All the data presented so far was also used in a secondary analysis meant to identify relations between variables, focusing in particular on patterns of engagement in component repair and in collaboration. As noted in the methodology section, the Pearson coefficient and the Phi-coefficient were employed. The complete correlation table alongside their level of significance can be seen in the annex.

The table includes age and size of the firms (in number of employees), their attitude towards component repair (whether they do it themselves, they externalise it or they do not do it), if they engage or not in collaboration networks, their training experience (university, self-taught, professional training and courses), whether they use second-hand parts in repair and whether they sell second-hand goods as part of their business model.

Results show that component repair is significantly and negatively correlated with self-taught training and university

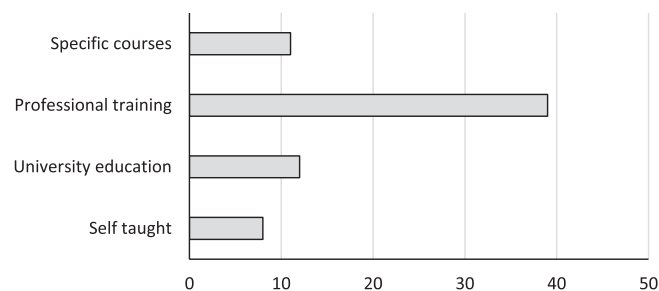


FIGURE 5 | Training and education of repairers. *Source:* Own elaboration from questionnaires.

training and significantly and positively correlated with having professional training. It is also positively correlated with engaging in collaboration networks; however, this relation is not significant under current conditions.

Externalisation of component repair is positively and significantly correlated with having been self-taught and it is negatively and significantly correlated with having professional training experience.

Not engaging in component repair, on the other hand, is positively and significantly correlated with size and age, and it is negatively and significantly correlated with using used parts in the repair process. It is also negatively correlated with engaging in collaboration networks, albeit the level of significance is between 0.05 and 0.1 and hence has exploratory value.

Engaging in collaboration networks is also negatively correlated with size and age, albeit not significantly, and it is positively and significantly correlated with having taken courses and repairing using used parts. It is also positively correlated with having university training (the level of significance is 0.051).

In the context of this research, these results indicate that component repair is more prevalent among repairers with professional training while it is also less prevalent among self-taught repairers and those with university studies. Not engaging in component repair is prevalent among larger and older firms and among those that do not engage in collaboration networks.

5 | Discussion

After presenting the results, their implications will be discussed in the context of the relevant literature review. The discussion will address how the results reflect on our understanding of the (independent) repair market and the implications for repair policy.

5.1 | The ICT Independent Repair Market

This paper addresses some novel aspects regarding the independent repair market, most of which have seldom been addressed in the literature. For instance, while collaboration is prevalent in DIY and community repair research, it has rarely been addressed in the professional repair industry. Similarly, component repair has seldom, if ever, been considered a factor in understanding the repair process and as a variable in repair research. These considerations help add an additional level of complexity and nuance to our current understanding of the repair industry and can serve as a departing point for more in-depth analysis of the repair industry.

Results show the increasing technical difficulty of repair. This points to a technological environment which is becoming more complex and hence requires more skilled labour. As a result, 42% of respondents claimed that they hire based on those needs. In addition to that, 33.3% of respondents claimed that they externalise part of their repair work, which mostly involves component repair and software. These results show that repair firms

can access the more advanced repair skills through hiring or through externalisation.

The difficulty in accessing information and obtaining spare parts also denotes an aftersales market controlled by manufacturers. This is a consequence of a production-consumption system incompatible with repair. There is a contradiction between a thriving repair culture and the current accumulation pattern that requires constant growth through sales and replenishment of saturated markets (Packard 1960; Vence 2023; Vence et al. 2024). Since the design process is controlled by manufacturers (Fry 2009; Packard 1960), there are no incentives for OEMs to engage actively with the independent repair industry. Consequently, they can refuse access to information and spare parts to perform repairs, which are for the most part acquired through third-party wholesalers (van der Velden et al. 2024; Türkeli et al. 2019). Both issues, lack of information and lack of spare parts, are noted as key barriers throughout the literature (Andersson et al. 2018; Terzioglu 2021; Graziano and Trogal 2017). This, paired with more complex designs, poses a threat to the independent repair market.

Two basic levels of repair were identified: module repair (changing a part) and component repair (changing a component inside a part or restoring a part without changing it). 52% of all respondents claimed that they do repair at the component level, either always or sometimes. 33.3% of respondents claimed that they externalise the procedure and only 11.7% of respondents claimed to never practice component repair. The importance of component repair cannot be downplayed. It allows for the independent repairers to operate without having to resort to OEMs' controlled spare parts market (Grinvald and Tur-Sinai 2019). Besides, component repair is a manifestation of the competence, innovativeness and creativity of repairers, which often takes the form of curiosity and propensity to tinker (Houston and Jackson 2016; Jackson 2014; Jackson et al. 2012; Berglund 2019).

Nonetheless, as technical designs become more complex, information takes a central role. Repair manuals, dismantling schematics and electric maps, among others, become key to perform component repair. In the world of community repair, information flows through collaborative networks which may even take the form of hackerspaces (Charter and Keiller 2016; Martinez and Laviolette 2019; Lepawsky 2020; Lepawsky et al. 2017). Repair knowledge has been found to be sticky in nature. Orr (1996) showed that in shops with multiple workers, the exchange of ideas and expertise took place through storytelling. Proximity and contact enhance trust and confidence and are the base upon which community repair initiatives are built (Bayraktaroglu and Idemen 2024). Part of the direct exchange in these spaces involves skill sharing and re-skilling (cf. Güsser-Fachbach et al. 2023; Parajuly et al. 2024; Korsunova et al. 2023). Questionnaire results show that independent professional repairers also participate in collaboration networks, similar to those in the community repair world. Most of these networks were internet-based, but many still relied on local direct contact. The nature of these networks involves skill-sharing as well as commercial and market inquiries, like repair exchanges and stock consultations.

All this indicates that repairers, even professional ones, participate and rely on the same or similar collaboration networks as community repairers do. This level of complexity makes repair similar to other knowledge-intensive industries, potentially due to the nature of knowledge and know-how and the difficulty of accessing it. Note that in knowledge-based activities the nature and the transmissibility of knowledge takes a central role. Lundvall (1999) distinguished 4 different forms of knowledge. Know-how and know-who tend to be very sticky and hard to codify, meaning that they tend to require interpersonal exchange. Know-what and know-why, on the other hand, are easily codifiable and exchanged. Know-how and know-who are critical for ICT repair since having the necessary skills and understanding the local repair network appear to be important for successful repair businesses, as shown in the results.

Results suggest that ICT repair is a knowledge-based activity that requires skilled labour and know-how and that independent ICT repairers tend to engage in collaborative networks that involve various forms of cooperation. These results contradict previous studies that had addressed local repair networks only as a threat to repair businesses (Andersson et al. 2018; Türkeli et al. 2019). This research shows that repair networks play a much more grey role. They undoubtedly mean competition, but they may also offer opportunities for cooperation, exchange, spillovers and skill sharing. Consequently, the common assumptions on the repair market ought to be reconsidered.

5.2 | The Implications for Repair Policy

This research is also relevant for policy design purposes. The European Repair Directive (2024/1789) has emphasised the role of OEM and OEM-associated repairers through the obligation to repair, a form of closed right to repair that removes barriers to repair only when going through official repair channels (Svensson et al. 2018). This obligation basically forces manufacturers, importers or their representatives to repair directly or through their affiliated repair services when asked by the consumer (López-Bermúdez and Vence 2024; López-Bermúdez and Vence 2025; Puentes 2024). The Directive has excluded from the regulation the independent repair sector, to the point that in the preparation work they explicitly acknowledged the potential danger that they could face: 'while repairers affiliated with producers would have increased revenue because of the obligation to repair, independent repairers who are not sub-contractors of producers might lose market share' (European Commission 2023, 55).

The product specific ecodesign regulation, passed under the now repealed Ecodesign Directive (2009/125)- now the Ecodesign for Sustainable Products Regulation (2024/1789)- introduced provisions regarding repairability, disassembly and availability of spare parts and repair information for independent repairers, creating a de facto form of right to repair. These regulations have imposed conditions on spare parts' supply and availability, meaning that they are useful for module repair, but not necessarily for component repair. Since most repairers actually engage in component repair, it could be useful to ensure that not only parts are accessible but that components themselves are

accessible as well. This could have a clear environmental advantage since the material cost of a component repair is much lower than a module one.

Designs that incorporate OEM parts and components are protected by Intellectual Property (IP). Discouraging the use of proprietary parts and components as part of design and ecodesign regulations could be extremely useful for repair. It would allow independent repairers to avoid the OEM supply of parts and components and use standard alternatives. The usage of serialised parts should also be discouraged since they require specific codes to link them to the devices, again granting control over the repair to the OEMs.

Regarding information, the ecodesign provisions ensure access but only after registration on an online platform and subject to fees, which can *de facto* exclude small and generalist repairers. The systemic lack of information has been a constant handicap to independent repairers for decades (Packard 1960; Krebs and Hoppenheit 2022; Orr 1996). This research shows that independent repairers find ways to overcome this lack of access by relying on collaborative networks and 'subversive spaces' (Martínez and Laviolette 2019). The current product-specific ecodesign regulations incorporate specific information items that must be made available. All this information could easily travel through the already established collaborative channels. Repair policy could help the independent repair sector by removing a fundamental threat to independent repairers, which is IP protection of repair information, which would allow information exchange without fear of prosecution (Dalhammar et al. 2023; Svensson-Hoglund et al. 2023). Another key policy reform could involve making repair information available for free, this would remove the price barrier and facilitate access in a context where the sticky nature of the know-how already poses an obstacle to transmission (Lundvall 1999; Orr 1996).

6 | Conclusions

Repair is an emerging topic in academia and policy. This research expands upon our current understanding of repair practices by examining how independent repairers overcome some of the most pressing barriers. This research addressed some novel issues in repair literature: component repair and the role of collaboration in the independent repair market. In order to conduct this research, quantitative data and methods were used, which are valuable in a field of research that has relied mostly on qualitative data due to the difficulty of compiling, codifying and quantifying information. Consequently, this paper strongly contributes to the existing literature on repair and barriers to repair and it helps contextualise and adds nuance to our understanding of the independent repair market.

At the forefront of repair obstacles is the production-consumption system, which is not conceived to be restorative. This is the result of an accumulation dynamic that requires constantly expanding markets and is incompatible with life extension practices (Packard 1960; Vence 2023). This creates barriers to repair and forces repairers to work against the designs rather than alongside them. This paper showed how this process shapes the independent commercial repair market and what are some of

the more pressing policy consequences. Previous research has shown that there is a thriving independent repair market which is highly distributed territorially (Stahel 2013; López-Bermúdez and Vence 2023) and which possesses valuable knowledge and know-how on the technologies that shape our daily lives and are a fundamental source of our material wealth.

This research shows that independent repairers continue to perform component repair and that it is a practice widespread across the sector. This allows a repair to take place outside the OEMs' control, since it does not require a new spare part. However, component repair requires specialised knowledge and know-how. Lack of information has been noted as a key barrier. This research shows that repairers have found ways to acquire and exchange knowledge and know-how and to engage in commercial and market cooperation by means of engaging in collaboration networks, most of them locally based. These Findings, albeit exploratory, suggest a positive relation between engaging in collaboration networks and component repair, while firms not engaging in component repair tend to be less prone to participate in collaboration networks. Overall this suggests that ICT repair is more alike to other knowledge-based industries, given the central role of know-how, the difficulty of accessing it and the unclear barrier between cooperation and competition.

For future research it is important to address the dual nature of a thriving repair environment. It represents both a threat and an opportunity for repair businesses and their commercial viability. This research is also relevant from a policy perspective. The repair policy mix in Europe is built around the European Repair Directive (2024/1799) and the ecodesign norms for specific product categories under the now repealed Ecodesign Directive (2009/125) and the Ecodesign for Sustainable Products Regulation (2024/1789). The current framework does not decisively support independent repairers but rather the OEMs' official repair services (López-Bermúdez and Vence 2024, 2025; Nogueira 2024). Policy measures could decisively support independent repairers by making spare parts cheaper, facilitating access to the components inside the parts, removing IP barriers over designs and information and by making repair information free, all of which would facilitate its transfer. The relevance of supporting the independent repair industry has to do with its regionally disseminated and knowledge-intensive nature. This can create resilience in the face of economic and environmental instability by keeping the ICT network and infrastructure in working order. This would also help democratise access to services provided by the existing technological stock and help regain control over societal ICT stocks.

Regarding limitations, it must be noted that results are circumscribed to one specific sector which is ICT repair. Consequently, discussion and conclusions apply to said sector and even though extrapolation is possible, given that some of the patterns observed are common to other EEE equipment, this must be done with caution. Regarding the methods used, the phi coefficient is highly sensitive to imbalanced marginal distributions, phi assumes both variables are true (natural) dichotomies and that expected cell counts are not too small. When expected frequencies fall below conventional thresholds (< 5), the coefficient becomes unstable and interpretations should be made with caution, as there is a risk of underestimation. In addition, phi captures only

linear association and may fail to represent more complex or nonlinear relationships between categorical variables. The use of phi in this study is explicitly exploratory, aiming to identify potential patterns rather than to make definitive statistical claims on the strength of association. Note that, in any case, relations are supported by theory, which helps contextualise the empirical observations. The research was also geographically limited to Galicia. These geographical constraints tend to be common in research working with questionnaires, interviews and case studies. Sample size, the exploratory nature of the study and the sectoral and geographical scope must be taken into account regarding the generalizability of the findings. Future research should continue to explore the role of collaborative arrangements and knowledge-sharing, while also noting the potential differences which component and module repair represent for repair work.

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Conflicts of Interest

The authors declare no conflicts of interest.

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Appendix A

Interview guide (Original was in Galician language)

1. What is your job?
2. How long have you been working on it?
3. What process do you follow when a breakdown occurs?
4. How does the spare parts market work?
5. What are the suppliers?
6. Is it difficult to obtain them?
7. Are they protected by intellectual property?
8. Do you take care of all the technical aspects?
9. When do you go to the manufacturers' service?
10. How important are manuals and schematics?
11. How did you learn? Studies? Experience?
12. Does maintenance influence the buying decision?
13. Is obsolescence a problem?
14. Do you observe changes in the last years?
15. Are repairs becoming harder or easier?
16. How do you feel about your job?
17. Do you find differences with other jobs?

	EMP	ANOS	COMP	Ext comp	No comp	Collab	No collab	Form self	FORM UN	FORM FP	Form cours	Used parts
EMP	1	0.285* (0.028)	-0.081 (0.537)	-0.148 (0.260)	0.343** (0.007)	-0.168 (0.20)	0.168 (0.20)	-0.163 (0.212)	-0.012 (0.926)	-0.016 (0.905)	-0.18 (0.168)	0.06 (0.648)
ANOS	0.285* (0.028)	1	-0.166 (0.205)	-0.008 (0.952)	0.269* (0.038)	-0.219 (0.093)	0.219 (0.093)	0.108 (0.410)	-0.2 (0.125)	0.167 (0.203)	-0.278* (0.031)	0.076 (0.562)
COMP	-0.081 (0.537)	-0.166 (0.205)	1	-0.782** (0.0)	-0.402** (0.001)	0.187 (0.153)	-0.187 (0.153)	-0.335** (0.009)	-0.218 (0.095)	0.390** (0.002)	-0.091 (0.490)	0.076 (0.561)
EXT COMP	-0.148 (0.260)	-0.008 (0.952)	-0.782** (0.0)	1	-0.257* (0.047)	-0.048 (0.717)	0.048 (0.717)	0.347** (0.007)	0.177 (0.177)	-0.296* (0.021)	0.122 (0.354)	0.171 (0.191)
NO COMP	0.343** (0.007)	0.269* (0.038)	-0.402** (0.001)	-0.257* (0.047)	1	-0.219 (0.092)	0.219 (0.092)	0.01 (0.938)	0.078 (0.554)	-0.169 (0.198)	-0.038 (0.773)	-0.370** (0.004)
COLLAB	-0.168 (0.20)	-0.219 (0.093)	0.187 (0.153)	-0.048 (0.717)	-0.219 (0.092)	1	-1000** (0.0)	-0.166 (0.206)	0.254 (0.051)	-0.053 (0.687)	0.313* (0.015)	0.269* (0.038)
NO COLLAB	0.168 (0.20)	0.219 (0.093)	-0.187 (0.153)	0.048 (0.717)	0.219 (0.092)	-1000** (0.0)	1	0.166 (0.206)	-0.254 (0.051)	0.053 (0.687)	-0.313* (0.015)	-0.269* (0.038)
FORM SELF	-0.163 (0.212)	0.108 (0.410)	-0.335** (0.009)	0.347** (0.007)	0.01 (0.938)	-0.166 (0.206)	0.166 (0.206)	1	-0.196 (0.133)	-0.432** (0.001)	0.068 (0.608)	-0.007 (0.959)
FORM UN	-0.012 (0.926)	-0.2 (0.125)	-0.218 (0.095)	0.177 (0.177)	0.078 (0.554)	0.254 (0.051)	-0.254 (0.051)	-0.196 (0.133)	1	-0.507** (0.0)	-0.022 (0.870)	0.035 (0.793)
FORM FP	-0.016 (0.905)	0.167 (0.203)	0.390** (0.002)	-0.296* (0.021)	-0.169 (0.198)	-0.053 (0.687)	0.053 (0.687)	-0.432** (0.001)	-0.507** (0.0)	1	-0.194 (0.137)	0.094 (0.474)
Form cours	-0.18 (0.168)	-0.278* (0.031)	-0.091 (0.490)	0.122 (0.354)	-0.038 (0.773)	0.313* (0.015)	-0.313* (0.015)	0.068 (0.608)	-0.022 (0.870)	-0.194 (0.137)	1	-0.086 (0.512)
Used parts	0.06 (0.648)	0.076 (0.562)	0.076 (0.561)	0.171 (0.191)	-0.370** (0.004)	0.269* (0.038)	-0.269* (0.038)	-0.007 (0.959)	0.035 (0.793)	0.094 (0.474)	-0.086 (0.512)	1

Note: * $p < 0.05$; ** $p < 0.01$.