

## Article

# Recycling Technology Innovation as a Source of Competitive Advantage: The Sustainable and Circular Business Model of a Bicentennial Company

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**Abstract:** La Farga Yourcoppersolutions is a bicentennial Catalan company that manufactures semi-finished copper products. As copper is a 100% recyclable material, much of the sector's production comes from secondary copper, scrap, not from mined copper. In the case of La Farga, not only a good part of its output comes from recycled copper, but it is also a world leader in copper-recycling technology. The objective of the paper is to describe La Farga's business model from the point of view of sustainability and the circular economy. What have been the causes and effects of recycling on the business model? Regarding the methodology, the work follows the research strategy of the case study. Both qualitative and quantitative data were collected from a variety of primary and secondary sources. Economic, social and environmental sustainability of the firm was assessed through financial and non-financial indicators; value-added generation and distribution were calculated from accounting data; and the circular business model was analysed via a thematic analysis: its components, innovation, enablers and barriers. Results show that the presence of barriers forces the implementation of circularity to be gradual and to combine linear and circular models to maintain competitiveness.

**Keywords:** ESG performance; circular economy; circular business model innovation; copper industry; recycling technology; waste upcycling; copper scrap



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## 1. Introduction

The European Green Deal, a growth strategy to transform the European Union into an equitable, prosperous and competitive society, using resources efficiently, with no emissions of greenhouse gases by 2050 and with economic growth dissociated from resource use, endorses this case study of a circular and sustainable business model that is based on copper recycling.

The recycling of copper means that less copper is extracted from mines and that we do not abuse the extraction of natural resources and put our planet at risk. It is worth noting that only 12% of the materials used in the industry are recycled since the industry is too linear and dependent on extraction methods in order to commercialise its products [1].

The circular economy provides the opportunity to develop technology, such as in the case of La Farga, to use recycling in pursuit of a more sustainable economy. Consistent with the European Green Deal, industrial strategy is reflected in the circular economy, with the development of circular products, as is the case with copper. The circular design of products such as copper, with the appropriate technology, impulses the circular business model in firms with intensive use of resources. Offering a recycled and competitive product is the challenge of La Farga's industrial model.

The action plan of the circular economy includes the use of reusable and recyclable products to facilitate the survival of a business, as is the case of La Farga. Additionally,

having reliable information and quality seals consolidates a firm's commitment to the circular economy. The financial and non-financial information that enables us to evaluate transparency and value created highlights a firm's ability to adapt to its surroundings, despite economic, social and environmental challenges. Furthermore, the circular economy minimises residue and prevents negative externalities throughout the life cycle of products, optimising the use of resources to generate efficient systems and overcoming the linear business model. The acronym ESG contemplates environmental, social and governmental aspects. It facilitates the transparency needed by organisations nowadays to gain the trust of their stakeholders and the wider society, and comprises the key information for making socially responsible investment decisions. ESG takes into account the effect the company has on the environment, both directly and indirectly; considers the company's impact on its local surroundings; and refers to the corporate governance of the company. Moreover, the pandemic caused by COVID-19, as well as financial and social world crises, have propelled ESG at different levels [2–4].

This investigation aims to highlight the importance of integrated information (financial and non-financial) in circular business models as a means for companies to offer transparency and trust to society and stakeholders, especially in the context of ESG.

La Farga Yourcoppersolutions (La Farga) is a Catalan company that has been recycling for more than 200 years. It manufactures and sells semi-finished copper products, such as wire rods, cables, drawn wires and tubes. Since copper is a 100% recyclable material, a significant proportion of world production proceeds from recycled or scrap, copper and not from mined copper. However, in the case of La Farga, not only is a large part of production from recovered copper, but nowadays, recycling also constitutes its distinctive capability and its main source of competitive advantage. On the one hand, nowadays, La Farga is the main copper recovery centre in the south of Europe. On the other hand, it is a world reference in recycling technology. The company has sold its process patent and transferred knowledge to more than 30 production plants around the world. Additionally, it opened the Copper Museum, which is the only museum in Europe dedicated exclusively to the red metal. The Museum disseminates knowledge and educates on the history, properties, use and recycling of copper.

Therefore, La Farga puts the principles of the Circular Economy into practice, although it may not use this term, and engaged in it before it became fashionable. Owing to the company's significant elements of circularity, the case of La Farga offers interesting empirical material to study the concepts related to the circular economy and sustainability. However, so far, the company has not been analysed through the lens of the circular business models framework. What are the causes and effects of recycling? What caused the company to place recycling in the centre of its strategy? How has recycling defined the business model of the company?

The aim of the article is to analyse the business model of La Farga from a circular economy and sustainability point of view. To be more specific:

1. Analyse the sustainability of the company, from economic, social, environmental and good governance points of view;
2. Calculate the value generated by the company and its distribution among factors of production;
3. Examine the circularity features of the company's business model;
4. Classify the circular business model of La Farga according to the typology of Lüdeke-Freund, Gold and Bocken [5];
5. Analyse the type of circular business model innovation in the company;
6. Explore the factors that have hindered or driven the adoption of the circular business model in La Farga.

After this introduction, in the next section, we review the literature on economic, social and environmental sustainability indicators; on the generation and distribution of value added from an accounting point of view; on circular business models and on barriers to the implementation of the circular economy. Then, we explain the methodology used to

carry out the case study. Afterwards, we present the case of La Farga, which is the core of the article. We describe the properties of copper, review the history of the company, compile financial and non-financial indicators of La Farga and examine the components of the circular business model of La Farga: value proposal, delivery, creation and capture. Finally, we discuss the results and extract the main findings.

## 2. Literature Review

Reviewing the literature on sustainability indicators reveals that the circular economy is a relevant, but not new, concept that is currently gaining traction due to the negative effects of the linear model [6], which greatly affects climate change and environmental and social imbalance. The industry, which has a linear business model and is dependent on extraction methods in order to commercialise its products, needs circular business models [7]. Specifically, the circular economy improves sales [8], supply chains [9], business models [7,10], the Product–Service System [11] and the management of many sectors [12–17]. Furthermore, the circular economy facilitates sustainable development [18] and requires financial and non-financial indicators for its management and control [19]. Therefore, a circular business model is fundamental for tackling the urgent problems of climate change and sustainability, and the European Union (EU), with the reports, plans and activities known as the circular economy package, intends to expand the circular economy model around Europe [20]. Additionally, according to current literature, the circular economy is a driver of the sustainable manufacturing sector, with the goal of regenerating resources [21].

Various authors have presented circularity indicators [4,22–24] in line with environmental, social and good corporate governance indicators, such as the indicators defined in the CII-FESG Integrated Scoreboard and the XBRL (eXtensible Business Reporting Language) of the Spanish Accounting and Business Administration Association (AECA), accepted by European regulators, in tune with the Global Reporting Initiative (GRI). The indicators are organised into three blocks: environmental indicators (energy consumption, water consumption, contaminating emissions and the generation, management and reuse of waste); social indicators (on human capital, social capital and human rights, anticorruption and bribery) and finally corporate governance indicators (referring to directors, executive board, audit committee, meetings and remuneration of directors, along with gender diversity among directors, corruption and bribery).

It should be noted that the ESG (Environmental, Social, Governance) criteria are key for investment decision-making and for encouraging more sustainable finances in pursuit of a sustainable development that integrates financial and non-financial indicators [2]. Environmental problems are well known nowadays, and companies and regulating agencies perceive the importance of environmental, social and governance activities (ESG) [3]. Furthermore, the ESG criteria are fundamental in establishing a circular economy model [4]. The aim of the Next Generation EU fund is to drive a more ecological, digital, resilient Europe, one that is flexible enough to adapt to the challenges faced now and in the future by means of substantial project funding and grants to help repair the economic and social damage caused by COVID-19 [25]. Additionally, in line with the European Green Deal, it seeks to create a more circular economy, which on the one hand will help the EU to reduce its dependence on external suppliers and on the other hand, increase its resilience to global supply issues. On this, the recycling of copper is key due to its high electrical conductivity and its use in the manufacturing of cables and electronic components, among others; furthermore, it is a metal that is infinitely recyclable, widely used in a multitude of sectors, around the world.

Moreover, the European Commission has launched a new Strategic Investment instrument to incentivise industrial and business leadership in key ecosystems. The aim is to promote a more circular economy by reducing waste generation, boosting recycling and increasing the use of secondary raw materials. Thus, the new investments in recycling will help assure strategic secondary raw materials in the application of the Circular Economy Action Plan [26].

It should be borne in mind that there is no general consensus about the circular economy at an industrial level [6,27–29] and that there are substantial differences in the controls that should be applied in the circular economy [21,23]. In particular, there are various conceptual studies and a lack of business case studies that address the circular economy on a practical level, to provide insights on production processes, materials used and of the challenges inherent in the circular economy in companies [30–32], such as case studies of companies concerned with metal recycling.

The academic literature explains that recycled metals are an important source of supplies, with a lower environmental impact than primary metal and in the case of recycled copper, a lower energy consumption than that of mined copper [33]. Thus, recycled copper is more beneficial for the environment than refined copper [34]. Therefore, recycled material, such as copper, facilitates circular economy business models and its non-financial and circularity indicators reflect the environmental advantages [35] for these companies. It should be noted that special attention is paid to environmental indicators in the circular economy [36], since environmental and economic objectives are the foundation of the circular economy [37], along with social and good governance indicators [6,38]. Therefore, environmental indicators are used to evaluate the production and recovery processes of the circular economy; governance indicators are related to qualitative assessments of infrastructure and managerial aspects of companies and social indicators are tied to human resources.

Another important aspect of the circular economy is the generation and distribution of value added. A review of the literature contemplates the legislation of value added, according to the Spanish Association of Accounting and Business Administration (AECA) [39]. In particular, a methodology for calculating and presenting value generated by the company is proposed, as well as the distribution among the different factors that have contributed to its generation. Value added is defined as the difference between revenue and costs incurred of goods bought in from other companies, namely, the cost of all prime raw materials, materials and services necessary for manufacturing. The remainder is shared between the different factors that have played a role in its generation: personnel (salaries), shareholders (dividends), capital providers (interest), government (taxes) and retained earnings (reserves, depreciation, impairments or provisions). The relevance of this concept stems from the studies carried out for the valuation of companies [40] which show that approaches based on added value can be more efficient than other more conventional approaches (the Ohlson model). In the twenty-first century, the prominent authors who have highlighted the interest in including data on value added in business information come from countries such as India [41] and South Africa [42].

The scarcity of resources and environmental pollution afflicting planet Earth underline the unfeasibility of the current economic model, based on the linear take–make–use–dispose flow of resources. Nowadays, the Circular Economy is considered to be the most promising method for pursuing sustainability [17]. In a circular economy, growth is not connected to the consumption of scarce resources [43]. The paradigm of the circular economy rests on three principles: (1) “preserve and enhance natural capital by controlling finite stocks and balancing renewable resource flows, (2) optimise resource yields by circulating products, components, and materials at the highest utility at all times in both technical and biological cycles, and (3) foster system effectiveness by revealing and designing out negative externalities” [44] (p. 22).

The ReSOLVE framework developed by the Ellen MacArthur Foundation is a set of six business actions to implement the principles of the circular economy: regenerate, share, optimise, loop, virtualise and exchange. Particularly, the loop business action means keeping components and materials in closed loops and prioritise inner loops. For finite materials, a loop involves remanufacturing products or components and, as a last resort, recycling materials [44]. Recycling products is the reverse cycle for the circular economy to apply when inner reverse cycles are not feasible, such as repair and maintenance, reuse and redistribution or refurbishment and remanufacturing. Material recycling is the

process of recovering materials for the original purpose or for other purposes, excluding energy recovery. Downcycling and upcycling are two types of recycling. Downcycling is “the process of converting materials into new materials of lesser quality and reduced functionality”, while upcycling is “the process of converting materials into new materials of higher quality” [45] (p. 25). According to Braungart et al. [46], downcycling does not enable a circular, “cradle-to-cradle” flow of resources, but maintains the linear “cradle-to-grave” flow of resources from production to waste.

The implementation of the principles of the circular economy through business actions requires the design of viable and sustainable business models [47]. The notion of a business model is considered a new unit of analysis, which bridges traditional units of analysis, such as the firm or the network [48]. “A business model describes the rationale of how an organization creates, delivers, and captures value” [49] (p. 14). Generally, business models are descriptions of (1) the value proposition made to costumers, (2) how the value proposition is delivered to customers, (3) how value is created and (4) how the company captures a portion of the created and delivered value [48].

Based on a review of definitions of circular business model, Geissdoerfer et al. [10] (p. 7) proposed a unified definition of circular business models as “business models that are cycling, extending, intensifying and/or dematerialising material and energy loops to reduce the resource inputs into and the waste and emission leakage out of an organisational system”. The global purpose of circular business models is to assist firms in creating value through using resources in multiple cycles and reducing waste and consumption [5].

Lüdeke-Freund et al. [5] built a morphological box of circular economy business model design options, an information system made of four major business model dimensions and eight subcategories: value proposition (products and services), value delivery (target customers and value delivery processes), value creation (key partners and stakeholders and value creation processes) and value capture (revenues and costs). Each subcategory of the morphological box contains some options to design the business model subcategory in question. The resulting matrix offers a huge number of theoretically possible combinations (more than four million, choosing only one design option per category) that researchers and practitioners can choose to create circular business models. Additionally, Lüdeke-Freund et al. [5] applied the morphological box to develop a typology of six major circular economy business patterns: repair and maintenance, reuse and redistribution, refurbishment and remanufacturing, recycling, cascading and repurposing and organic feedstock business models.

Otherwise, there is the subject of how companies can transform their business models to increase their degree of circularity [50]. The concept of circular business model innovation refers to the process of innovating the business model to embed, implement and capitalise on circular economy practices [51]. In this regard, Geissdoerfer et al. [10] identified and described four circular business model innovation strategies: circular start-ups, circular business model diversification, circular business model transformation and circular business model acquisition.

Finally, another significant research stream on circular economy focuses on the identification of barriers preventing companies from adopting circular economy business models, and enablers that help them to overcome the obstacles [52–55]. For instance, Tura et al. [54] identified drivers and barriers of the circular economy; classified them into seven categories: environmental, economic, social, institutional, technological and informational, supply chain and organisational factors; and examined their influence on the adoption of circular economy through four firms’ case studies. Similarly, Rizos et al. [52] explored the barriers and enablers experienced by 30 small and medium-sized enterprises in the implementation of circular economy business models. They found that the main barriers are lack of support from the supply and demand network, lack of capital, lack of government support, administrative burden and lack of technical know-how; meanwhile, the main enablers are company environmental culture, networking, support from the demand network, financial attractiveness and external recognition.

### 3. Materials and Methods

The investigation of the causes and effects of recycling on sustainability and circularity was conducted through a case study of La Farga Yourcoppersolutions. A case study is a suitable empirical model for the research question since it asks the “why” and “how” questions, and because it allows for in-depth exploration of the contemporary phenomenon, within a specific context, over which the researcher has no control [56]. Furthermore, the study broaches a technically distinctive situation in which there are many more variables than observations at play. Additionally, previous theoretical developments already exist, which can guide the design, collection and analysis of data, which come from multiple sources and need to be triangulated [56].

#### 3.1. Data Sources

The information used was both quantitative and qualitative and obtained from various sources, both primary and secondary. First, we consulted the previous work of Serra and Bayón [57], Pascual and Nadal [58], Pascual [59] and Tàpies et al. [60] to summarise the history of the company and identify the main events in its timeline. Furthermore, we searched the press database MyNews Hemeroteca [61], in order to obtain recent information on the development of the company. Next, we obtained accounting and corporate information from the Iberian Balance Analysis System database [62]: the balance sheet, income statement and cash flow statement.

The sustainability reports were an essential source of data. Since 2006, La Farga has published an annual sustainability report, in which its financial, social and environmental performance are held accountable to its internal and external stakeholders. The Global Reporting Initiative (GRI) standards constitute the best practices at a global level for disclosing the impacts of an organisation [63], and are in line with the United Nations' Global Pact and Sustainable Development Goals. La Farga's reports are based on the G4 version of the Sustainability Reporting Guidelines of the GRI, according to the highest level, “core-comprehensive” and are subject to verification by an external audit firm, for which they were awarded the A+ rating. Examining La Farga's sustainability reports enabled us to collect quantitative information (such as non-financial indicators, R & D investment or production volumes) and qualitative information (about strategy, structure, products, processes and stakeholders: shareholders, employees, clients, suppliers, the local community and the government).

Furthermore, we inspected various documents in order to analyse components of the circular model of La Farga. From the product catalogues of La Farga, we obtained information on value proposition, delivery and creation: features of the products and services, client segments, quality certifications and homologations. We searched the Patentscope data [64] for patents registered to the company. The websites of organisations such as OmniSource [65], Steel Dynamics [66], SDI LaFarga [67], Continuus Properzi [68] or the Centre of Design and Optimization of Processes and Materials [69] yielded information about the key partners of La Farga. From the studies by Roig and Quintanilla [70], Vilà and Bosch [71] and Pascual [59] and the company's accounts, we gathered information on value capture. Moreover, we revised the website of the Copper Museum [72] in order to investigate its business model.

Besides qualitative and quantitative secondary data, we also collected qualitative primary data. On the one hand, we interviewed three members of the senior management of the company, from the production, marketing and communication areas. The interviews were semi-structured and were conducted using a script with open-ended questions, in which we predetermined the information required [73]. The interviews enabled us to expand, delve into and contrast the data obtained from the secondary sources on the circular business model of La Farga. On the other hand, on three occasions, we personally visited the Copper Museum and Factory of the company, located at the headquarters in Les Masies de Voltregà. Furthermore, we disposed of a variety of information on such

a renowned company, which has been part of the local socio-economic environment for decades, thanks to other similar studies on companies from the region of Osona [74–76].

### 3.2. Data Analysis

With respect to the analysis of accounting information, on one side, we compiled a value-added statement, using the information from the income statement and cash flow statement. The analysis of the generation and distribution of value added allowed us to explore the creation and capture of the value of the circular business model of La Farga. We calculated the value generated over a period as the difference between revenue and the costs of all prime materials, materials and services needed for manufacturing. We also calculated the distribution of value added between the different factors that have played a role in its generation: employees, shareholders, capital providers, the government and earnings retained by the company.

Moreover, with the aim of evaluating the economic sustainability of the company, we performed an economic and financial analysis. From the information provided in the balance sheet and income statement, we calculated the financial indicators of the subsidiaries La Farga Lacambra, La Farga Tub, La Farga Rod and La Farga Intec in 2008 and 2017 and of the company created after the merger, La Farga Yourcoppersolutions, in 2018 and 2019. Through the financial indicators, we analysed the evolution of turnover, profit, short-term solvency (the ratio of current assets to current liabilities), indebtedness (the ratio of debt to net equity plus liabilities), economic profitability (the ratio of profits before interest and taxes to total assets) and financial profitability (the ratio of net profit or loss for the period to net equity).

The analysis of the environmental, social and good governance sustainability of La Farga was carried out through an assessment of the company's key non-financial indicators related to energy efficiency, emissions, efficiency in waste management, human capital, social capital and corporate governance.

The remainder of the information collected (sustainability reports, product catalogues, press, interviews, etc.) was analysed using thematic qualitative analysis [77]. With the help of the qualitative data analysis software Atlas.ti 9 [78], we reduced the information via a system of pre-determined top-down categories and subcategories, connected to the theoretical framework of Lüdeke-Freund et al. [5]. In this way, we selected quotations of the documents, codified them using a list of descriptive codes of the business activity and clustered them according to the morphological box of circular economy business model design options of Lüdeke-Freund et al. [5]. Thus, to the codes "Continuus Properzi", "Ganzhou Jiangwu", "Danieli", "SDI La Farga" and "Research centres and universities", we assigned quotations related to those topics and clustered them under the subcategory "Key partnerships". With the set of codes and the relationships among them, we constructed a network to represent the circular business model of La Farga.

## 4. Results: Case Study of La Farga

### 4.1. Copper: An Infinitely Recyclable Mineral

Copper was the first metal to be used by man, and since prehistoric times has been crucial to the progress of humankind. Man's early tools, made from flint and stone, were replaced by a much more reliable and resistant material: copper. One of the most important stages in human history is named after a copper alloy: The Bronze Age [79].

Copper is both an excellent electrical conductor and thermal conductor. In addition, it is a versatile, ductile and durable material [80]. The antimicrobial properties of copper have long been known, and it is playing an increasingly important role in healthcare: the antimicrobial properties of copper and copper alloys against SARS-CoV-2, viruses and bacteria have been demonstrated in hundreds of scientific, peer-reviewed articles and the US Environmental Protection Agency (EPA) has announced that some copper alloys provide protection against viruses, including SARS-CoV-2. This means that products may now be marketed with the claim that they kill certain viruses, since they are the first and

only products to provide residual virucidal efficacy [81]. Around the world, copper is used in high-touch surfaces, such as handrails, gym equipment and in schools and restaurants.

A major benefit of copper is that it is 100% recyclable: it can be recycled over and over again without any loss to its properties or performance. Since it is infinitely recyclable, copper is one of the best renewable resources and is critical in building a circular economy. Given its highly efficient conductivity, renewable energy systems use 12 times more copper than conventional systems. In addition, highly efficient systems need less energy to produce electricity, which in turn lead to lower CO<sub>2</sub> emissions [80].

As an essential resource, the applications of copper are diverse. The transport, medical, manufacturing, technology and renewable energy sectors, as well as the food chain, all rely on the properties of copper. The use of copper around the world is rising due to its use in technology and industry innovation and its role in the development of a sustainable society [80]. According to the US Geological Survey, since 1950 there have always been 40 years of reserves of copper, and 200 years of resources (resources include reserves, potentially profitable deposits and predictions of deposits that are still to be discovered) [79].

Copper will play an essential part in meeting society's future needs, including renewable energy, healthcare, efficient transportation and communications. The industry continuously carries out research into innovations that will reduce the use of natural resources and energy consumption and lessen the impact on the environment. Such innovations will require versatile materials. Copper alloys, which are a result of adding other metals to copper, increase the properties and performance of copper, meaning that applications can be developed which meet future needs [79].

#### 4.2. History of La Farga

In 1808, Francesc Lacambra i Pont, apprentice tinsmith and scrap metal dealer, established a small foundry in the neighbourhood of La Barceloneta, close to the port of Barcelona, to produce copper and bronze objects, such as pots and nails (see Appendix A for a timeline of the company). The foundry prospered thanks to the growing demand for all types of tools used in the building of factories and ships. In addition, he dealt in wholesale metal that he bought in the port: in particular, old copper proceeding from the renovation of fuselage and ships, which he used to produce sheets, which were then sold to the Mint of Barcelona (Casa de la Moneda). In 1852, he built a forge in an old flour mill on the banks of the River Ter, at Les Masies de Voltregà, 60 km away from Barcelona (Figure 1) [57].

In 1913, after expanding the facilities and investing in new machinery, the company started manufacturing wire rods for electric cables. During the First World War (1914–1918), the company enjoyed a great financial boom. In 1914, the Lacambra family built a modernist-style residence next to the factory, as well as housing for the workers. Over the following decades, the electrical and railway industries became the main markets of La Farga. However, in 1936, when the Spanish Civil War broke out, the workers' unions collectivised the company and the Lacambra family fled Catalonia. In 1937, the Republican Government seized the company, deeming it essential for the war effort, and used it for military purposes. When the war ended in 1939, the family was able to go back, and the company was returned to them.



**Figure 1.** Current location of the company’s headquarters, on the banks of the River Ter, at Les Masies de Voltregà (Barcelona).

From the 1950s onward, the company was able to resume its industrial investment. It built a hydro-electric plant next to the River Ter, acquired a bar and wire rod rolling mill and increased its production capacity. It refocused its business on drawing plates and gained new clients, such as Pirelli, Seat and Saenger. It built a colony for the workers in Vinyoles and sponsored numerous social and sporting activities: a pharmacy, shop, cinema theatre, bar and restaurant, etc. The greatest development took place between 1959 and 1975, with an increase in the production of wire rods for the main car manufacturers of Spain. However, after 1976, with the arrival of democracy in Spain, the position of the company declined: it lost market share, its debt increased excessively and an increase in direct costs led the company to the brink of bankruptcy. In 1979, unable to meet payments to suppliers, the Lacambra family commissioned the law firm Castejón y Asociados to carry out a viability study. In 1980, four partners of the law firm created La Farga Lacambra, S.A., which took over the management of the company “Francisco Lacambra Lacambra”, and the Lacambra family ceased their ownership of the company. The partner Vicente Fisas took over the strategic commercial and legal management and his son-in-law, the partner Oriol Guixà, headed the industrial restructuring project.

Oriol Guixà identified that a key strength of the company lay in its experience in using recycled material and refining scrap copper, and posed radical and innovative changes: “Until then, from a technical point of view, it was thought that the metal recycling processes, and in particular of copper, didn’t allow continuous casting. But we put our faith in implementing continuous casting. In 1986, La Farga launched the first continuous casting process using recycled copper in the world. It was a wise decision, a success, and a technical contribution to the industrial world, which opened a huge niche in the market, and enabled us to be much more competitive than our competitors and increase the company’s profile. With the patent for the process, we started selling our technology around the world.” [82] (p. 188).

Setting up the continuous casting of recycled copper pushed the company into a new era of continuous investment and accelerated growth: it installed a new smelting furnace for copper cathode to increase the use of the rolling mill and increase the range

of products (1987); it installed (1989) and extended (1990) a new wire drawing section and started manufacturing welding wire for the food-canning industry, and it built a new factory to manufacture thermo-hydro-sanitary tubes (1992). In 1993, as a result of a crisis in the copper market (stagnated demand, excess supply and a drop in the price of copper) and excessive debt, the company had to open a new proceeding for suspension of payments. However, on this occasion, the company was able to survive the crisis thanks to its key strengths: high productivity, quality products and services, ideal geographic location and highly qualified human resources, and to a strategic change: “The premises were clear: eliminate all the casting process using purified material, and focus on recycled material ( . . . )” [71] (p. 7), [57].

In 2000, the company overhauled the foundry with a revolutionary process improvement, called Cosmelt Process, which enabled the continuous smelting, cleaning, refining and casting of scrap copper. As a result of investments in previous years, during the first decade of the twentieth century, the company went through a phase of great expansion of its productivity, production, sales and market share. Production increased from 83,751 tonnes in 1998 to 152,704 in 2008. At the same time, the company undertook environmental investments, such as building a cover for the scrap yard and installing a new fume treatment plant. Furthermore, in 2001, the General Board of Shareholders agreed on a family protocol, which regulated the access of partners and family members to jobs within the company. The Fundació La Farga (La Farga Foundation) was created in 2004 to support social, cultural and educational initiatives in the surrounding area; in 2008, coinciding with the 200th anniversary of the company, the Fundació La Farga opened the Copper Museum.

During the 2010s, La Farga diversified its products and markets. Due to continued research and development efforts, it created high performance mechanical and electrical copper products and introduced alloys of copper and other materials, such as tin, silver and magnesium, to the railway, aerospace and automobile sectors. The new products, along with a multitude of patents, certifications and homologations, boosted the internationalisation of the company. It returned with force to the railway market with a new complete range of catenary cables for railways. It participated in railway electrification projects across the five continents: normal, high speed, metro and tram lines. The joint venture Ganzhou Jiangwu La Farga High-Speed Railway Copper Materials was launched in 2010 to manufacture and distribute copper and alloy railway products in the Chinese market. Moreover, two companies were created in 2011 and 2013 to distribute copper tubes abroad, which contributed to the European expansion of La Farga Tub: La Farga Tub France, in France and La Farga Limited, in the United Kingdom, supplying the French and British markets, respectively. In 2012, the joint venture SDI La Farga was launched in the United States to produce recycled copper wire rods for cable manufacturers in the Americas. In addition, 30 production plants in 16 countries had been equipped with La Farga patented recycled technology by 2011. In 2018, 45% of La Farga’s 1049-million-euro turnover came from exports: 34% from the European Union and 11% from outside the European Union.

In 2016, the main subsidiaries of the family owned group La Farga were three manufacturing companies, one service company, two distribution companies and a foundation. La Farga Lacambra manufactured semi-finished copper products using recycled material and copper cathode. La Farga Tub manufactured copper tubes, and La Farga Rod manufactured electrolytic copper wire. La Farga Intec handled the sale of patented recycling technology and planned the group’s expansion. In 2018, these companies, located in Les Masies de Voltregà, were merged into La Farga Yourcoppersolutions, S.A. On the other hand, the Fundació La Farga, while not legally linked to the group, promoted and supported cultural and educational activities in the surrounding area: The Copper Museum being its most important cultural initiative [83].

#### 4.3. Sustainability of La Farga

In this section, we examine the economic, social and environmental sustainability and the corporate governance of La Farga. Using financial and non-financial indicators,

compatible with circularity indicators, we analyse the sustainability of the companies that were subsidiaries of the La Farga group until 2018, which is when they were merged with La Farga Yourcoppersolutions.

The financial indicators of the subsidiaries La Farga Lacambra, La Farga Tub, La Farga Rod and La Farga Intec show different economic and financial situations (Table 1). During the period 2008–2017, the non-current assets of La Farga Lacambra increased by 55%. A 13% increase in turnover was not reflected in the bottom line, which decreased by 71.3%, causing a decrease in financial profitability of 5.23% and in economic profitability of 2.37%. Moreover, indebtedness stood at 69%, liquidity was acceptable and the workforce increased by 45% between 2008 and 2017.

**Table 1.** Financial indicators of the subsidiaries of the group (2008–2017).

	La Farga Lacambra		La Farga Tub		La Farga Rod		La Farga Intec	
	2008	2017	2008	2017	2008	2017	2009	2017
Non-current assets <sup>1</sup>	25	38.9	12	18	16	14	4.53	0.0006
Net equity <sup>1</sup>	33.7	43.2	18	15	16.7	16.15	1.33	−0.424
Turnover <sup>1</sup>	393	442	88.5	101	360	776	0.95	0.022
Profit and loss for period <sup>1</sup>	7.8	2.2	0.083	−0.499	0.044	3.1	0.068	−0.983
Indebtedness	49%	69%	28.44%	67.35%	59%	75%	73.07%	451.92%
Short-term solvency	1.42	1.15	1.82	1.01	1.29	1.06	0.27	0.22
Financial profitability	23.39%	5.23%	0.45%	−3.82%	0.27%	19.59%	5.16%	−231.49%
Economic profitability	17.61%	2.37%	1.55%	−1.43%	2.26%	7.35%	4.01%	−815.47%
Workforce <sup>2</sup>	155	226	80	97	22	25	2	n/d

<sup>1</sup> Million euros; <sup>2</sup> number of employees.

The non-current assets of La Farga Tub increased by 47% and turnover by 14%, although equity decreased by 17% as a result of the losses at the end of the period analysed. As a consequence, the financial and economic returns dropped to negative values in 2017, in tune with indebtedness of 67% in 2017, potential liquidity issues and an increase in the workforce of 21%. As for La Farga Rod, long-term investment fell by 13%, equity did not change and turnover increased by 115%, which was reflected in an increase in the profits and financial and economic profitability. This was despite indebtedness of 75% in 2017, a reduction in short-term solvency and a 14% increase in the workforce. Regarding La Farga Intec, there were significant reductions in non-current assets, net worth, turnover and losses, which caused an increase in debt and negative financial and economic profitability.

Finally, from the merger in 2018 until 2019, La Farga Yourcoppersolutions held 83 million euros in non-current assets and experienced a 3.6% decrease in turnover, which led to a loss of 2.8 million euros in 2019: a negative financial profitability of −4.81% and a negative economic profitability of −0.87%. The financial structure of the company shows the use of borrowed capital was 70%, and moderate short-term solvency, with potential difficulties in meeting short-term payments (Table 2).

**Table 2.** Financial indicators of La Farga Yourcoppersolutions (2018–2019).

	2018	2019
Non-current assets 1	83.2	82.9
Net equity 1	63.12	60.17
Turnover 1	1.048	1.011
Profit and loss for period 1	1.357	−2.896
Indebtedness	71.75%	70.94%
Short-term solvency	1	0.94
Financial profitability	2.15	−4.81%
Economic profitability	0.99%	−0.87%
Workforce 2	396	349

<sup>1</sup> Million euros; <sup>2</sup> number of employees.

The non-financial indicators include environmental, social and good governance indicators. Table 3 shows the values of the environmental indicators of La Farga Yourcoppersolutions between 2015 and 2018. The average energy consumption per tonne of copper processed was 1253 kWh/t; water consumption was 0.87 m<sup>3</sup>/t and CO<sub>2</sub> emitted into the atmosphere was 271.38 kg/t. Of the residue generated (8.4 Kg/t), most of which was non-hazardous, 16% was reused, including copper and other material. The values of the environmental indicators associated with the production of 206,851 tonnes of copper in 2018 were in tune with the previous years: water consumption of 0.91 m<sup>3</sup> per tonne of copper processed, energy consumption of 1269 kWh/t and CO<sub>2</sub> emissions of 268.64 kg/t. The environmental cost of the company's commercial activity, certified with the ISO 14001 international environmental management standard, was balanced.

**Table 3.** Environmental indicators of La Farga Yourcoppersolutions (2015–2018).

	2015	2016	2017	2018
Energy efficiency and emissions				
Energy consumption (kWh/t)	1209	1301	1234	1269
Water consumption (m <sup>3</sup> /t copper processed)	0.81	0.98	0.78	0.91
Contaminating emissions (t/year)	75,369	84,441	80,075	82,668
CO <sub>2</sub> emissions (kg/t copper processed)	263.00	273.56	280.32	268.64
Waste management efficiency				
Waste management (Kg/t copper)	9.51	7.78	6.95	9.49
Non-hazardous waste managed	81%	62%	72%	78%
Waste reused	15%	18.85%	13.77%	16.17%
Tonnes of copper produced	218,053	231,210	248,441	206,851

With regard to the social human capital indicators, the average size of the workforce between 2015 and 2019 was approximately 400 employees, most of them men (87%). Workforce stability was 80% and absenteeism 5%. Workers were given on average 12,600 h of training (Table 4). In 2018, there were 396 employees, 12% of whom were women, 77% had a permanent contract and 91% lived in the county where the company is located (Osona). Finally, the company ensured the workplace health and safety of its employees, as demonstrated by obtaining the ISO 45001 certification.

**Table 4.** Human capital indicators of La Farga Yourcoppersolutions (2015–2018).

	2015	2016	2017	2018
Employees	347	406	429	396
Gender diversity of employees	Men 87% Women 13%	Men 90% Women 10%	Men 82% Women 18%	Men 88% Women 12%
Senior management positions	16	19	18	16
Gender diversity in senior management	4	4	5	5
Employee stability	84%	80%	79%	77%
Absenteeism	3.57%	5.32%	5.46%	5.98%
Employee turnover	8%	10%	10%	18%
Net job creation	27	34	43	13
Labour seniority	10.71	9.64	8.89	9.05
Employee training (hours)	9288	12,968	17,220	10,756

Regarding the social capital indicators, and in particular clients, the company has a Planning and Service Area within the supply chain to improve management, reduce inefficiency, improve service and reduce the delivery time of the product. Thanks to the Value for the Client project, La Farga also fulfils its commitments and maintains constant contact with its clients, which is a differentiating feature. Additionally, the company seeks the highest level of coordination between the purchasing and selling of copper because the markets are closely related. With regard to the relationship with suppliers, the main aim of purchasing is to obtain maximum efficiency, quality and range of products, with a flexible and reliable supply and with sustainable relationships that foster long-term relationships with suppliers.

As for the corporate governance indicators, the Board of Directors, represented by the family and outside advisors, ensures the long-term viability of the organisation and protects the interests of the public and the organisational values and culture. Furthermore, it safeguards financial, social and environmental matters and takes an interest in the prevention of occupational risks with transparency and responsibility, in tune with the quality management, environmental and health and safety certification systems. Moreover, the president of La Farga is responsible for supervising that the Board of Directors carries out its duties correctly and efficiently and that in economic, environmental and social matters, all legal requirements are met. The General Board of Shareholders, which determines the remuneration of the members of the Board of Directors, specifies the economic, social and environmental aspects, on an objective and fair basis, according to the director's duties, individual performance and contribution to the bottom line.

In terms of the score of the indicators used to evaluate ESG, La Farga identifies 100% of the information on environmental indicators (6/6) in its sustainability reports. Regarding social indicators, it provides 83% of the information (10/11) since it does not report on social information related to relationships with customers and suppliers, although it specifies the fulfilment of commitments made with clients and sustainable relationships with suppliers. In reference to corporate governance indicators, it details 20% of the information (2/10), namely, on directors and their gender. Therefore, during the period 2015–2018, the global ESG score of La Farga is 67% (18/27). This information has an impact on investment decisions since it facilitates the recognition of the company's environmental and social commitments and the attractiveness of socially responsible investments.

#### 4.4. The Circular Business Model of La Farga: Value Proposition

La Farga defines itself as “a leading, innovative metal-producing company that manufactures semi-finished copper products and their alloys for the electrical, metal packaging,

railway, tubes, automotive, billets and special conductors markets. Above all, La Farga is a family business, one that is committed to innovation and that has been focused on sustainability since its inception. We are an international name of reference in terms of recycling technology. We are continually innovating to promote efficient connectivity, using those resources necessary for each type of application and to a single purpose: to achieve optimum solutions for both our clients and for the environment in which we live. We are proud of our commitment to society and with the La Farga Foundation, we are involved in a broad range of social, training and cultural initiatives, one of these is our Copper Museum, the only one of its kind in Europe” [84].

#### 4.4.1. Products

The company classifies its product portfolio into nine lines: wire rod, wire drawing, welding wire, tubes, railway cables, earthing strands, special cables, overhead lines and billets (Table 5). Copper wire rod is hot-rolled copper bar of a minimum of 8 millimetres in diameter which is sold in coils. It is a semi-finished product, which is used to produce wire and cables. Essentially, La Farga offers two types of wire rod: Genius, “the only 100% recycled copper wire rod with maximum efficiency; a more profitable solution for you and a more beneficial one for the environment” and Essential, “a range of electrolytic copper wire rods for performance with high conductivity demands. This range includes electrolytic copper rod, oxygen-free copper and copper alloys (magnesium, tin and silver)” [84].

**Table 5.** Semi-finished copper and copper-alloy products of La Farga.

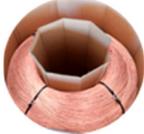
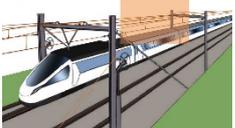
Product	Description	Image
Copper rod	<i>Genius:</i> 100% recycled copper rod: Frod, Cu-FRHC (Fire Refining High Conductivity). <i>Essential:</i> high conductivity and purity electrolytic rod, obtained from grade A cathode, for demanding conductivity situations: Premiumrod, Cu-ETP1 (Electrolytic Tough Pitch); Ofrod, oxygen-free; Tinrod, CuSn, copper–tin alloy; Argentrod, CuAg, copper–silver; Magnesiumrod, CuMg, copper–magnesium	
Copper wire drawing	Semi-finished to produce electrical cables, oxygen-free and tinned: Unifil, rigid copper wire; Plurifil, stranded parallel copper wire; Rigidcord, rigid strands; Flexicord, flexible strands	
Welding wire	Joinfil, poly micro-alloy copper wire for welding metal packaging for the food-canning industry, aerosols and cosmetic products	
Copper tubes	Wide range for plumbing, gas, heating, solar power, air conditioning, medical gases and industrial uses: Sanitub, Sanicrom, Climatub, Climaplus, Sanistar, Saniheat, Meditub, Indutub and Level Wound Coil	
Railway cables	Range of materials for catenary: Railfil grooved contact wire, contact wire, feeder, hangers and cables: copper, copper–tin, copper–silver and copper–magnesium; for conventional, metro, tram and high-speed lines	

Table 5. Cont.

Product	Description	Image
Earthing strands	Earthing cables for buildings to prevent electrocution, accidental contact and surge protection: Earthing Rigidcord, ECCC-I (Earthing Copper Coated Conductor Industrial), ECCC-AT (Anti-Theft), ECCC-AC (Anti Corrosion)	
Specialcables	High content copper alloys, with extensive mechanical and electrical features for the railway, aerospace and automotive sectors: CuOF, oxygen-free copper; CuAg, copper-silver; CuSn, copper-tin; CuMg, copper-magnesium	
Overhead line conductors	CAC (Copper Alloy Conductor), high-temperature micro-alloyed conductor, designed for low-, medium-, high- and very high voltage overhead lines	
Billets	Copper cylinders for the production of copper pipes, bars, profiles and plates: Fbillet	

La Farga groups its trademarked products into “advanced materials”. The Brand Ecocopper™ differentiates its copper products as being products that are “made from 100% recycled material and help save resources and energy ( . . . ); Furthermore, together with our customers we design all products where Ecocopper™ is applicable in order to help create copper solutions with lower environmental impact but with the same qualities and characteristics as products using mined copper”. Other brands of La Farga include Evelec™ and Evelhis™, a highly resistant grooved contact wire, for conventional and high-speed railway lines, respectively; and La Farga Advanced Materials, with alloys of copper with other materials. Additionally, La Farga offers a 50-year guarantee with the installation of its tubes and also informs that copper is the only metal that has been certified by the EPA (US Environmental Protection Agency) as an antimicrobial agent.

#### 4.4.2. Services

La Farga offers a take-back service to its customers of welding wire. The service consists of taking the used wire away (the dirty copper), refining it, turning it into high-purity micro-alloyed wire and delivering it back to the client. This circular service is profitable for clients because La Farga only charges them the processing costs, with a consequent saving in the purchase of raw material. The clients also save on logistical costs, since La Farga removes 100% of waste material. On the other hand, the company recovers other materials sent to the client, such as packaging and wooden reels.

Traditionally, this type of transaction was commonplace at La Farga: clients sent their raw material and La Farga processed it and delivered the finished product. Under this “processing system”, the clients are also suppliers. At the end of the 1970s, when the company was in a critical financial position, some clients, such as Pirelli, started to refuse to supply the company with old and new copper because of the amount of money the company owned them for previous deliveries of raw material. On that subject, Oriol Guixà said, “when we started, the company even owed money to its clients” [85] (p. 63). As time went on, the company reduced these processing operations and started buying secondary material from scrap dealers [71].

Moreover, technology transfer has been an essential line of business for La Farga. The revolutionary technology of continuous casting using recycled metal that was developed

in 1986 entailed cost savings in the production of wire rod so substantial that the company immediately started selling the technology in collaboration with the Italian machinery manufacturer Continuus-Properti. The technology was perfected over time, and the results of the process improved in terms of quality, reliability and sustainability. Thus, offering know-how transfer to foundries was added to the company's range of products, as well as semi-finished copper products. In addition to the licensing of the production process patent, La Farga offers technical support and training services, both at the company's plant at Les Masies de Voltregà, and in situ at the clients' plants. Other services offered are financial advice for investors on setting up the new venture, starting the business project and its subsequent management: inventory management, purchasing, sales, etc.

The Copper Museum is also an emblematic part of La Farga's business. In 2008, coinciding with the company's two-hundredth anniversary, the Fundació La Farga opened the Copper Museum in collaboration with the University of Vic, which steered the museum and museum project. The Museum is located in a modernist-style house, which was built at the beginning of the twentieth century at the old Lacambra colony and which had been the summer residence of the Count and Countess Lacambra. Under the motto "Copper: a conductor of history", the Museum is organised into five areas: "La Farga: a company history", "Copper and the origins of metallurgy", "Chemical element copper", "Technology and applications of copper" and "Production process of the transformation of copper". The last area consists of a walkway through the foundry, casting and wire drawing plants, where one can see the production process of La Farga in real-time. The Museum is considered to be the only museum in Europe decided exclusively to the red metal.

#### 4.5. The Circular Business Model of La Farga: Value Delivery

##### 4.5.1. Customer Segments

La Farga operates in organisational or B2B markets, and not in consumer or B2C markets. The clients of the company are also companies, which buy the semi-finished products and copper alloys to use in the manufacturing of their own products or to sell them on to others [86]. In 2017, La Farga had 454 clients: 36% belonging to La Farga Lacambra, 51% to La Farga Tub and 13% to La Farga Rod. Table 6 shows the main market segments of La Farga's products. Electric cable manufacturers are the main buyers of copper wire rods, which produce electric cable using a process of wire drawing or cold wire drawing and which is then covered in enamel or plastic. Metal packaging manufacturers buy the welding wire and use it to hermetically seal canned food, aerosols, or cosmetics. Wholesale companies and retailers, such as plumbing, heating and refrigeration warehouses, buy the tubes from La Farga. The warehouses then resell the tubes, mainly to the building trade.

Railway infrastructure construction firms are the clients of railway cables, such as Alston or Siemens. In conventional, metro, tram and high-speed lines, La Farga supplies the material for catenaries, which is the overhead line that supplies electricity to a locomotive. The clients of the railway infrastructure construction firms are governmental bodies, such as ADIF in Spain, SNCF in France, or DB in Germany. Other clients of La Farga are the railway, aerospace and automobile sector, which buy special cables; the transport and electric power distribution sector, which buy overhead line conductors; and copper tube, bar, profile and plate manufacturers, which buy billets.

From another perspective, regarding the destination of the company's products, La Farga is in part vertically integrated: that is to say, it supplies semi-finished products to itself. For example, a fraction of the production of wire rods is used to manufacture drawn wire, and billets are used for tubes. Additionally, the company owns two copper tube distribution warehouses, La Farga Tub France and La Farga Limited UK and it holds 40% of the capital stock of two copper and aluminium distribution businesses: Vicente Torns Distribution and Vicente Torns Distribution France [83].

**Table 6.** Customer segments of La Farga.

Customer Segment	Product
Electrical cable manufacturers	Thermal wire rod
Enamellists, plate manufacturers, cable manufacturers	Electrolytic wire rod
Electrical cable manufacturer	Drawn wire
Metal packaging manufacturers	Welding wire
Plumbing, heating and refrigeration warehouses; industrial applications manufacturers	Tubes
Railway infrastructure construction firms	Railway cable
Electrical warehouses	Earthing strands
Railway, aerospace and automotive sectors	Special cables
Transport and electric power distribution sector	Overhead line conductors
Copper tube, bar, profile and plate manufacturers	Billets
New foundries	Sale of technology
Tourists, pensioners, associations, educational centres, groups of students	Copper Museum

The clients of the patented continuous casting technology are not competitors of La Farga. The technical and financial support is offered to both investors who want to set up a new production plant and commercialise semi-finished products made from recycled copper and to foundries that already use La Farga technology. During the first decade of the twenty-first century, demand for La Farga's recycled copper refining systems and continuous casting process increased due to society realising the importance of recycling copper [87]. Until 2011, 30 production plants had been equipped with technology from La Farga and machinery from Continuuus-Properti, situated in 16 countries such as South Korea, India, Italy, Cuba, Saudi Arabia, Russia, Mexico, Iran, Ukraine, the United States, China, Pakistan or Azerbaijan. On this, Oriol Guixà stated, "We're very proud because La Farga's standing in the world of copper recycling is very high" [82] (p. 188).

As for clients of the Copper Museum, visits are classed as internal and external. Internal visits include clients, suppliers and workers; while the main profile of external visitors to the Museum are, first, groups of students and educational centres, and in second place, tourists, pensioners and associations. The educational offer of the Museum is adapted to the academic levels of the students: primary school, secondary school, A-levels, vocational training and university. The educational offer includes guided tours, with commentaries, around the Museum's collection and the foundry. The exhibition contains resources that foster interaction between the student, the guide and copper, such as games, questions and mythological tales. Additionally, workshops such as "The Story of Venus", "The Story of Cu", "Magic box", "Taboo game" and "Home-made electric engine" are given. The Museum provides teachers with educational resources: dossiers, activities and exercises, to use before, during and after the visit.

#### 4.5.2. Value Delivery Processes

La Farga seeks to continuously communicate with its clients. With the aim of "satisfying the current needs of the client, anticipate their future needs and identify new opportunities and trends" [88] (p. 57), the company launched the project "Value for the client". It consists of a coordinated structure of sales representatives and technicians to dialogue with the client: the front office, responsible for the sales agreement and budget compliance; customer service, which ensures customer satisfaction and the quality account manager, who ensures quality and technical support. La Farga also has other communication channels with its clients: catalogues, a sales team, annual customer satisfaction

indexes, a complaints system, a technical advice service, website, attendance at trade fairs, mailing lists and specific campaigns [83].

#### 4.6. The Circular Business Model of La Farga: Value Creation

An analysis of the generation of value added, and its later distribution, allows information to be obtained on the value creation of the company. Value added is defined as the difference in revenue during a period and the costs of the raw materials, materials and services needed for production. Added value can be distributed among the different players involved in its creation: personnel (labour costs); shareholders (providing a return of capital, payment of dividends); creditors (providing a return of borrowed capital, interest); the state (taxes); and reserves (depreciation, impairments and provisions). Clearly, the more value added, the more the company is able to distribute value among the agents that contribute to its creation. There is therefore a relationship between value generation and value distribution.

We have calculated the added value for the subsidiary companies of La Farga until 2017, using their income statements, on the basis of the net amount of turnover and procurement costs. Table 7 shows value added, expressed in millions of euros and as a percentage of turnover. The resulting values indicate the capacity of value distribution among the factors that contribute to its creation (an analysis of value distribution is carried out below, in the Value capture Section 4.7).

**Table 7.** Value added of the subsidiaries of the La Farga group.

		2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
La Farga Rod	M EUR	4.5	6.3	6.9	7.5	8.0	10.5	13.5	12.0	11.3	13.9		
	% Income	1.2	2.3	1.3	1.2	1.3	1.9	2.4	2.1	2.1	1.8		
La Farga Tub	M EUR	12.3	6.6	8.7	12.8	6.3	11.0	11.0	9.9	1.3	11.3		
	% Income	13.9	9.4	8.6	11.6	6.2	11.5	11.6	11.6	1.6	11.2		
La Farga Intec	M EUR	-	0.9	1.4	1.1	1.2	1.1	1.7	1.3	0.7	-		
	% Income	-	90.3	97.2	99.6	100.0	99.1	100.0	99.6	100.0	-		
La Farga Lacambra	M EUR	33.5	5.7	38.3	30.3	33.7	40.6	34.2	36.3	21.0	41.2		
	% Income	9.3	2.1	7.4	5.0	5.6	7.5	6.0	6.2	3.9	5.3		
La Farga Yourcopersolutions	M EUR											40.3	39.8
	% Income											3.8	3.9

Millions of euros, % turnover.

La Farga Intec presents a higher added value as a per cent of turnover than the rest of the subsidiaries, in all the years analysed (Table 7). Such a high percentage is because La Farga Intec was the only service subsidiary, and therefore procurement costs are almost zero. Until the merger in 2018, La Farga Intec managed sales of patented recycling technology. An analysis of the proportion of value added on turnover of the other three subsidiaries from 2008 to 2017 reveals that La Farga Rod had the lowest proportion. La Farga Rod manufactured electrolytic rods using mined cathodes of mined copper. On the other extreme, La Farga Tub, which manufactured tubes, had the highest percentage of added value on revenue. La Farga presented values between the previous two subsidiaries. La Farga Lacambra produced semi-finished products using recycled copper and cathodes.

##### 4.6.1. Key Partnerships

Among the key partnerships of the business model of La Farga, the agreements for the sale of technology with the Italian firms Continuus Properzi and Danieli stand out, as well as the joint ventures Ganzhou Jiangwu-La Farga, in China and Steel Dynamics, Inc.—La Farga, in the United States. Collaboration with research centres and universities has also played a fundamental role in the development of the business.

In 1988, La Farga Lacambra signed a cooperation agreement with Lucio Properzi, representative of the Italian machinery manufacturing firm Continuus, in which the Catalan company would provide information about “a special reverberatory refining furnace and

the corresponding technology and know-how to turn scrap copper into smelted copper suitable for manufacturing wire rod . . . ” [58] (p. 646). Under the agreement, Continuus was responsible for selling the technology and overseeing installation worldwide, except in Spain and France, and if necessary, producing the machinery and installing metallurgical plants equipped with the technology [58]. Due to the strategic union of the technological knowledge of La Farga Lacambra, and the machinery building capacity of Continuus-Propenzi, for 25 years the firms fitted 30 new wire rod production plants, using continuous casting and recycled material, in 16 countries.

However, in 2013, the companies agreed to finalise their cooperation agreement, since both sides were interested in selling technology independently in the future [89]. After the contract with Continuus Propenzi, La Farga overhauled its strategy of selling technology: “Now the objective is to focus on clients to whom we know we can offer more added value, that is to say, not just the sale of the production process, but also our know-how of technical and business advice . . . ” [90] (p. 22). In 2017, La Farga signed an agreement with the Italian engineering firm Danieli, which specialised in the manufacturing of machines and plants for the ferrous-metals industry. The agreement was to enable La Farga to reinforce its strategic line of technology transfer in the copper and copper alloy sector and to enable Danieli to adapt its technological offering in copper processing and expand to the non-ferrous metal subsector [91].

In 2009 and 2010, La Farga signed two joint ventures, one in China and the other in the United States, to set up the respective industrial copper companies with local partners. The partnership Ganzhou Jiangwu-La Farga High Speed Railway Copper Materials was set up with two Chinese partners, one private and the other belonging to the Government of the province of Jiangxi, with the aim to manufacture and distribute copper and copper-alloy products for railway electrification in the Chinese market. La Farga held a 49% stake and contributed its technical knowledge of the railway sector, and the Chinese partners contributed their knowledge of the market and culture of the country [92]. However, La Farga sold its interest in Ganzhou Jiangwu-La Farga because of the difficulties in penetrating the Chinese market: “( . . . ) we have concluded that it is monopolised by the Chinese Ministry of Transport, which protects the 100% national manufacturers ( . . . ). On the other hand, we have started a technological support programme with our ex-partner, and we are negotiating knowledge transfer to other wire rod manufacturers in China Fire Refining High Conductivity” [90] (p. 6).

SDI La Farga, LLC was founded in 2012 in New Haven (Indiana, United States), the result of an association between La Farga and OmniSource Corporation, LLC, with a 45% and 55% share, respectively. The purpose of the new partnership was to smelt, cast and draw wire, using only recycled material, to meet the cable manufacturers’ needs in the Americas. The plant was equipped with a refining furnace with a capacity of 250 tonnes per day, and an FRHC wire rod production line of 30 tonnes per hour, both La Farga patented technology. Omnisource, with headquarters in Fort Wayne (Indiana), 10 km from New Haven, is one of the main scrap and recycled material distributors in North America. It is owned by Steel Dynamics, Inc. (SDI), which is one of the main steel manufacturers and metal recyclers in the United States, with more than 7700 employees. Thus, in the joint venture, SDI La Farga served as an expert in the market and supplier of raw material, and La Farga as an expert in the product and supplier of copper-recycling technology. After successive investments, such as a new, more efficient fuel system and a new scrap separation system, SDI La Farga has increased its productivity, reduced its energy consumption and enhanced its presence in the American copper wire rod market. In 2020, it had more than 80 employees and was planning to build a second furnace [65–67,91–93].

Collaboration with research centres universities goes as far back as 1988 when, as a result of the excellent results of the new continuous casting using recycled copper, La Farga Lacambra decided to go a step further and sign an agreement with the University of Barcelona “ . . . to optimise the annealing properties of recycled wire rod. The research programme aimed to improve the mechanical properties of wire obtained from thermal wire

rod" [58] (p. 637). Since then, the company has regularly collaborated with research centres and universities to improve the processes and products of copper recycling, develop new products, search for new high-performance materials and economic, energetic and environmental optimisation. The institutions include The Centre for Design and Optimization of Processes and Materials (DIOPMA) of the University of Barcelona, the School of Industrial Engineering of the Polytechnic University of Madrid, the Institute of Materials Science of Barcelona (ICMAB-CSIC), the RWTH Aachen University of Germany, the Technological Centre of Manresa, the Autonomous University of Barcelona, the Polytechnic University of Barcelona, the University of Vic—Central University of Catalonia, etc.

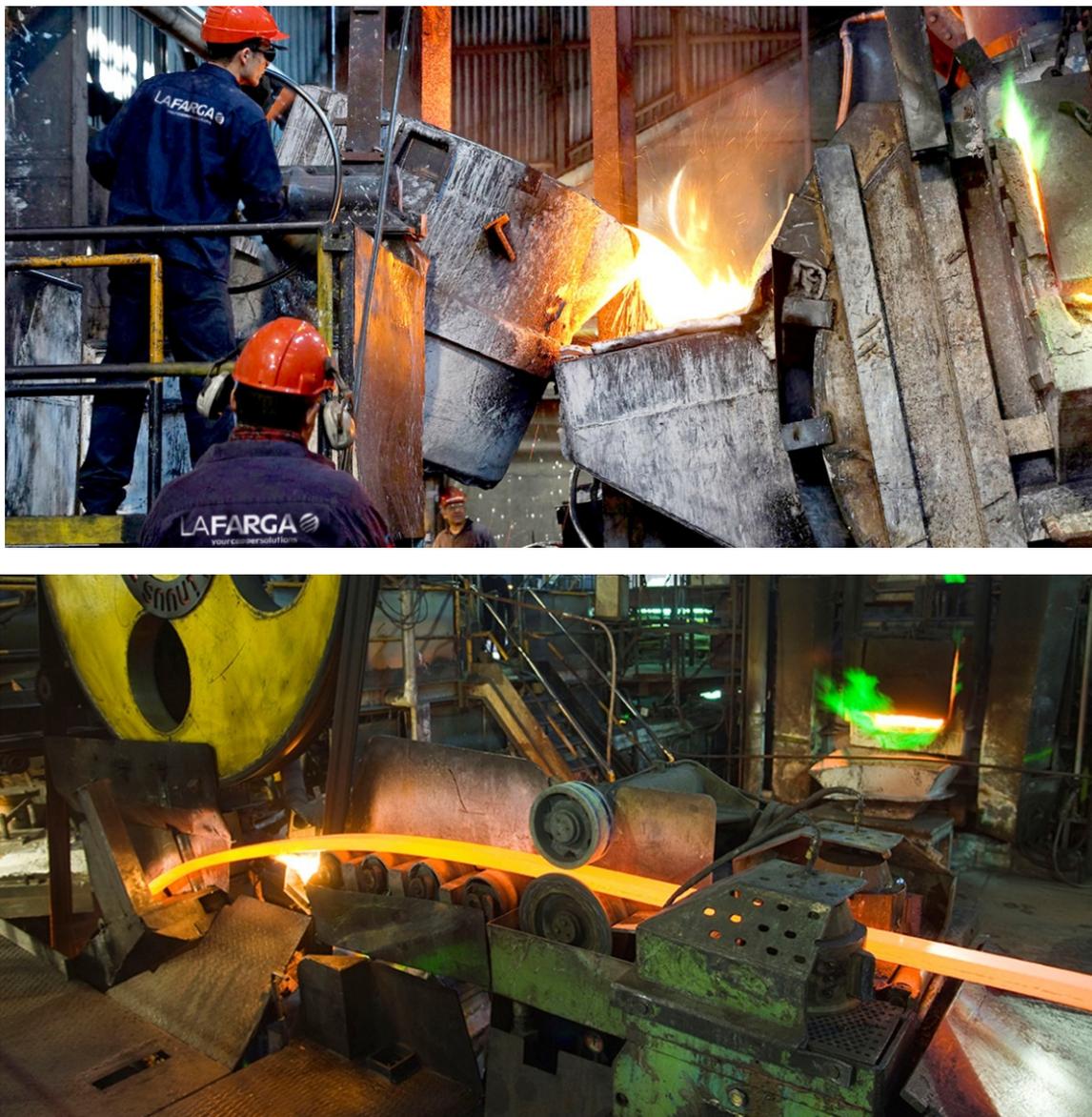
#### 4.6.2. Value Creation Processes

The essential value creation processes in the circular model of La Farga are, on the one hand, the key activities of copper recycling and R & D, and on the other hand, key intangible resources, such as knowledge, patents, certifications and homologations. The main value creation process of La Farga has traditionally been copper recycling. The revolutionary process of using continuous casting to manufacture wire rods from recycled copper, launched by La Farga for the first time in the world in 1986, was different to both continuous casting used copper cathode and the conventional process using scrap. The stages of the continuous casting process using scrap to produce wire rods are [57] (p. 210) (Figure 2):

1. Melting down and refining the scrap using the classical oxidation-reduction process.
2. Pouring the refined copper into a mould that continuously transforms it into solid bars at rolling temperature.
3. Hot-rolling the bars in a mill that, through successive steps, transforms it into a wire rod of an indefinite length.
4. Cleaning up or descaling, eliminating the superficial oxide and continuous cooling of the wire rod.
5. Coiling it onto spools of the desirable weight.

The new system was different to the cathode system because the primary furnace to smelt and refine the copper was totally different. It was also different to the conventional system of producing wire rods from scrap because it had a higher output, much lower energy consumption and because it eliminated the intermediate production of wire bar and it allowed for the production of wire rods of an indefinite length, the same, and using the same technology, as continuous casting using cathodes [58,94].

Through years of research, the company has perfected the process to reduce the amount of impurity in scrap copper. In the year 2000, it overhauled the foundry and patented and put into practice the Cosmelt Process, which allowed the continuous smelting, cleaning, refining and casting of scrap copper: "La Farga's Cosmelt Process is a pyrometallurgical process which generates zero solid waste, eliminates all impurities and minimises the environmental impact, since it reduces the number of stages of the recycling process. While other industries require a total of three production stages (through an electrolytic process), La Farga brings together the whole process in a single stage, which helps preserve the environment" [89] (p. 94). A total of 99.9% pure semi-finished products are achieved through this process, from 92% pure scrap copper. In 2018, La Farga invested 15 million euros in substituting, modernising and expanding the continuous casting line it had set up 35 years previously, which increased production capacity by 33% and made it the second-biggest in Europe. The new line maintained the essence of the recycling patent, and at the same time, incorporated the knowledge generated over time, resulting in greater efficiency, reliability, safety and sustainability [95] (p. 5).



**Figure 2.** Stages of the process of manufacturing wire rods.

As for R & D, in the 2018 annual sustainability report titled *Talent and innovation, our essence*, the company declares that its philosophy is “to constantly innovate and invest to improve”. For 3 decades, the management has strived to instil a “spirit of improvement and creativity in all areas of the company” [83] (p. 26). As a consequence, La Farga regularly allocates 5% of its net profits to R & D, for designing new materials, products and process that maximise energy efficiency and minimise environmental impact throughout the life cycle of the product. In 2018, 2,182,435 EUR was invested in R & D, which represents 20% of cash flow; in 2017, 1,879,026 EUR (60%); and in 2018, 3,360,839 EUR (33%) [83].

At its headquarters, the company has a research centre that reproduces the production process on a small scale; a laboratory to conduct quality testing; the Microscopia room, with a scanning electron microscope, able to magnify objects 30,000 times up to 15 KV, and a differential scanning calorimetry, for studying chemical reactions in materials subjected to high temperatures and a research management centre. Furthermore, the company has its own research centre at the University of Barcelona. Nevertheless, La Farga engages in open innovation [96]. As well as collaborating with external research centres and universities, it draws on ideas and knowledge from clients, suppliers and employees, to improve processes and products and to develop new products and new applications for copper.

As a prime example of an industrial company, the tangible assets (buildings, machinery, stock) of La Farga make up the bulk of the company's assets. Thus, the annual balance in 2018 shows that fixed assets plus stock (176 M EUR) make up 78% of the total assets (223 M EUR). Nevertheless, strategically, the main assets of the company are intangible. In effect, as a result of the sustained effort over time in research, development and innovation, La Farga has generated a valuable reservoir of knowledge or know-how, only partially reflected the company's accounts: in 2018, "intangible assets" represented only 4% of total assets (Table 8). Although a part of the company's know-how is implicitly embedded in the skills of staff, in organisational routines and in organisational culture, La Farga has also made its knowledge explicit through patents, certifications, homologations, trademarks, scientific articles and contributions to congresses.

**Table 8.** Percentage of intangible assets on total assets (%).

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
La Farga Rod	1.0	1.3	1.3	1.2	1.9	2.8	3.1	3.0	1.9	0.9		
La Farga Tub	0.3	1.5	2.5	2.6	2.0	3.0	2.2	4.9	2.9	3.5		
La Farga Intec	-	91.4	78.1	77.6	75.0	73.1	58.4	67.4	69.6	-		
La Farga Lacambra	0.7	1.2	1.6	3.3	4.7	6.0	5.4	5.7	5.4	4.5		
La Farga Yourcopersolutions											4.1	4.1

With the aim of protecting its know-how, La Farga has obtained a series of patents for product inventions and copper-refining and processing technology. In January 2021, 42 patents belonging to the company were listed in the Patentscope database [64], which provides access to international applications under the Patent Cooperation Treaty (PCT). The earliest was published in 1989: "How to improve the properties of copper rod obtained by continuous casting" (application number P8900898), while the most recent was in 2018, "Positioning verification apparatus for metal tubular pieces, verification equipment and positioning verification method" (18382070). Various patents are associated with recycling: with the optimisation of the recycling process using scrap copper, such as the "System and method for charging a furnace for melting and refining copper scrap, and furnace thereof" patent (P201331803); with improving products obtained from scrap, such as the "How to improve the properties of copper rod obtained by continuous casting" patent or with new products produced from scrap, such as the "Copper wire microalloyed for welding" patent (ES201031134A).

On the other hand, the different units in the company are certified according to the core standards of the International Organization for Standardization (ISO). La Farga Lacambra obtained the quality management system certification UNE-EN ISO 9001 in 1993, La Farga Tub in 1998, La Farga Rod in 2009 and La Farga Intec in 2009. La Farga Lacambra obtained the environmental management certification UNE-EN ISO 14001 in 2001, La Farga Tub in 2007, La Farga Rod in 2009 and La Farga Group in 2011. La Farga Lacambra obtained the OHSAS 18001 (Occupational Health and Safety Assessment Series), for occupational health and safety, in 2005, La Farga Tub in 2008 and La Farga Rod in 2009. Additionally, the Copper Museum obtained the SICTED certification (Integrated Spanish Quality System for Tourist Destinations) in 2013, which evaluates individual establishments and tourist destinations globally [97]. Currently, La Farga's quality, environmental and occupational health and safety management systems (ISO 9001:2015, ISO 14001:2015 and ISO 45001:2018) are integrated, and the company has the certification of an integrated management system.

The innovation and continuous improvement of La Farga (certified according to the international standards ISO 9001, ISO 14001 and ISO 45001) are also reflected by an Environmental Product Declaration (EPD), which verifies the environmental impact of a product along its life cycle, according to the standard ISO 14025. Specifically, the

Genius wire rod is certified as a high-conductivity copper product, especially suitable for manufacturing electrical conductors, which stand out for their performance, purity, quality and technical features, and which is 100% recycled. It also complies with the EN 15804 standard, established by the Product Category Rule (PCR), which is basic for the EPD certification, valid from 30 October 2020 until 23 October 2025. The certification describes the potential environmental impact of the product, in terms of global warming, the effect on the ozone layer, acidification, eutrophication and abiotic depletion; and details the energetic and aquatic impact, acceptable disposal and reuse of waste. In accordance with the EPD, it is presumed that the company will continuously quantify and improve the environmental impact of the product throughout its life cycle.

#### 4.7. The Circular Business Model of La Farga: Value Capture

Table 9 shows the generation and distribution of value added in 2018 and 2019 at La Farga Yourcoppersolutions, S.A., the company resulting from the 2018 merger of subsidiaries. Value added, which does not exceed 4% of turnover, is distributed almost equally between salary remuneration (46–43%, employee benefits and remuneration) and retained earnings (45–49%; depreciations, impairments, other operating costs, etc.). The remaining value added is allocated to capital providers (7–8.6%, financial expenditure). A part of the value is distributed to employees as net remuneration, and another part to payments to the Government, in the form of deductions and insurance for workers. With regard to shareholder remuneration, an analysis of the Cash Flow Statement (not shown) indicates that the company has not distributed equity capital in the form of dividends in 2018 or 2019. In contrast, dividend payments were made in the years before the merger, particularly by La Farga Rod and La Farga Lacambra. Finally, in terms of added value paid to the State, the company did not pay corporate tax in 2018 or 2019, since it made a loss and offset its losses.

##### 4.7.1. Revenues

Table 10 shows the revenue of the subsidiaries of the La Farga group. During the period 2008–2017, revenue for La Farga Rod was 49.6% of the group's turnover; revenue for La Farga Lacambra was 41.8%; La Farga Tub 8.5%; and La Farga Intec 0.1%. The group's revenue comes mainly from sales of La Farga Rod and La Farga Lacambra. In addition, revenue for La Farga Rod, which manufactured electrolytic wire rods using copper cathode, exceeds revenue for La Farga Lacambra, which manufactured semi-finished products using copper scrap and cathode. The difference between the two subsidiaries widened in the last few years, which may indicate a decrease in the degree of circularity of the group. Furthermore, a comparison of revenue (Table 10) with value added (Table 7) of the group's subsidiaries shows that La Farga Rod was the subsidiary with the highest turnover but with the lowest percentage of value added of revenue.

The bulk of La Farga's revenue comes from the sale of semi-finished copper and copper-alloy products: wire rod, drawn wire and welding wire, tubes, overhead cables, etc. Figure 3 shows the evolution of the annual copper production of the company. From mid-1980, production saw strong growth for 3 decades; from the 2010s, annual sales stabilised at around 200,000 tonnes.

The ability of manufactures to fix a price is extremely limited since copper is a commodity, which is "a good or service whose wide availability typically leads to smaller profit margins and diminishes the importance of factors (such as brand name) other than price" [98]. When rival companies' products are virtually indistinguishable, the product is a commodity and price is the only basis for competition [99]. Given specific objective technical features (purity, diameter, etc.), the copper produced by different companies is interchangeable, i.e., it does not matter which company manufactured it. The daily price at the London Metal Exchange (LME) is the world reference price of copper.

**Table 9.** Value-added statement of La Farga Yourcoppersolutions.

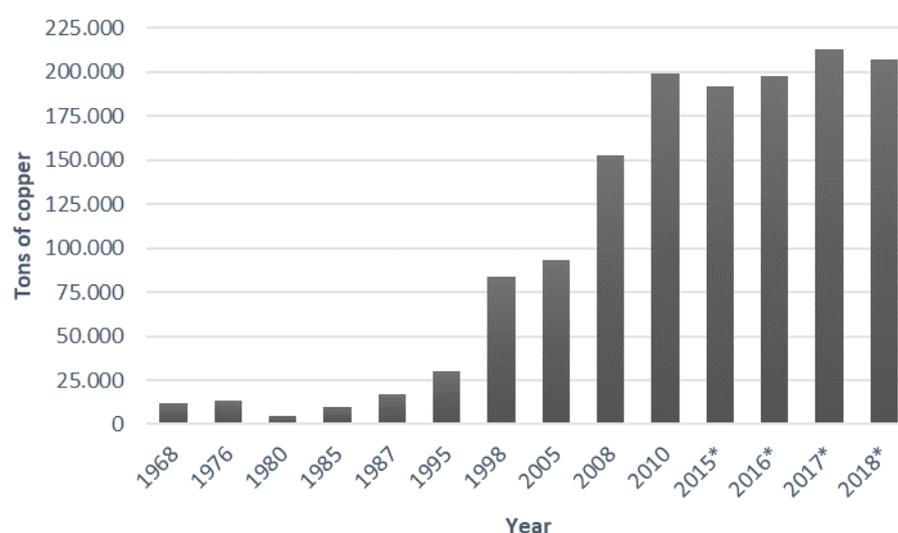
	2018		2019	
	M EUR	%	M EUR	%
Revenues	1048.6	100%	1011.2	100%
Costs of bought in goods and services	1008.3	96.2%	971	96.1%
Total gross value added	40.3	3.8%	39.8	3.9%
Employees (benefits and remuneration)	18.6	46.1%	17.5	43.9%
Shareholders (dividends)	0	0	0	0
Capital providers (financial expenditure)	3.5	8.6%	2.8	7.0%
Government (corporate tax)	0	0%	0	0%
Retained earnings (depreciation, impairments)	18.3	45.3%	20	49.1%
Total value added	40.3	100.0%	39.8	100.0%

Millions of euros.

**Table 10.** Revenues of La Farga.

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
La Farga Rod (1)	360.4	276.6	516.4	604.5	596.9	540.8	572.7	582.1	539.5	776.6		
La Farga Tub	88.5	70.5	101.5	110.4	101.9	95.7	94.8	84.9	76.1	101.2		
La Farga Intec		1.0	1.5	1.1	1.2	1.1	1.7	1.3	0.7			
La Farga Lacambra (2)	393.0	257.6	425.8	556.0	555.9	504.7	515.4	479.9	396.5	442.7		
La Farga Yourcoppersolutions											1.048.6	1.011.2
(1)/(2)	0.92	1.07	1.21	1.09	1.07	1.07	1.11	1.21	1.36	1.75		

Millions of euros.

**Figure 3.** Evolution of the annual copper production of the company (\* consolidated tonnes of copper sold).

At La Farga, during the first years of the introduction of thermal wire rods, obtained by melting down scrap copper using continuous casting, the sale price was slightly cheaper due to its lower quality compared to wire rod from cathode. “Thermal wire rod was well received by customers. La Farga offered them a product with a more than high enough quality to manufacture thick wire at a lower price than electrolytic wire rod” [70] (p. 82). Subsequently, continuous process improvements have allowed the company to perfect the quality, reaching a purity of 99.9% from 94% recycled copper [100]. Nowadays, the company refers to price only implicitly, for example, when it advertises the “100% recycled optimum efficiency and conductivity” Genius wire rod as “a more profitable solution for you and a more beneficial one for the environment” [84]. The poly micro-alloy welding wire Ecocopper, made from 100% recycled material, is even described as being superior quality, as it “has better mechanical properties and resistance to temperature than conventional copper wire” [84].

Although La Farga’s revenue comes mainly from the sale of semi-finished copper products, from 1990, the income statement registers a regular income of “provision of services”. This corresponds to income received for royalties on the sale of the technology for the continuous casting of scrap, developed at La Farga Lacambra by Oriol Guixà from 1984 to 1986. The collaboration agreement, signed between La Farga Lacambra and Continuus-Properti in 1988 for technology transfer, was for 10 years and specified that La Farga Lacambra would receive 405,000 USD in royalties for each of the production plants set up by Continuus-Properti [58]. Although the bulk of the sale of technology as a percentage of total turnover is small (less than 1%, between 1990 and 2006) [58] (p. 647), the company has always considered it to be a strategic line of business. In 2008, it set up the subsidiary La Farga Intec to support and encourage sales of a technology that was already known around the world, and of the added technical and financial services provided to new production plants that used the continuous casting process to manufacture recycled copper wire rod. Furthermore, the aims of La Farga Intec were to plan and manage the expansion of the metallurgical holding company and supervise invested companies, such as Ganzhou Jiangwu La Farga, SDI La Farga, La Farga Tub France, Vicente Torns Distribution, etc. [100]. However, in 2016, La Farga Intec was dissolved following a corporate restructuring, the aim of which was to “separate the activities in our home market from international activities carried out with our foreign partners ( . . . ) the income generated from the sale of technology to outside firms were invoiced by the industrial companies of the group, nullifying La Farga Intec, which was absorbed by La Farga Lacambra” [88] (p. 3).

The annual income of the Copper Museum, stemming, for example, from the sales of tickets and products, was 15,604.90 EUR in the year 2010. A total of 42,450 people visited the Museum in its first 10 years. A total of 1986 in 2018, of whom 57% were students (31 schools, 1126 students). The Museum regularly surveys its visitors on their level of satisfaction with their visit, and the average level of satisfaction is very high; for example, 9.8 out of 10 in 2018. Up until its opening in 2008, the Fundació La Farga had invested 3.5 million EUR in setting up the Copper Museum. On the profitability of the Museum, the president Oriol Guixà said, “I never thought the Museum would make a profit! But I have to admit that it’s been an important payback: people see that we’re thinking in the long term, about the future of the company, about prestige and future development. It’s important at all levels, it distils the family ethos, our vocation to remain, and that we weren’t looking to make a fast buck” [82] (p. 200).

#### 4.7.2. Costs

The recycling technology invented and implemented by La Farga in 1986 yielded a significant saving in the cost of buying raw materials. Scrap copper was much cheaper than copper cathode, which was the raw material traditionally used in continuous casting. The price of recycled copper is determined by applying “a discount” to the price of copper cathode, which is traded daily on the London Metal Exchange (LME). However, although the price of “old copper” is based on the trading price of “new copper”, other factors also

affect the price agreed in each transaction, such as the type of scrap (Berry, Candy, Clif . . . ), the supply and demand of scrap, among others. Thus, the discount on scrap purchases varies according to the market, with the consequent effect on gross profit margin: when recycled copper is scarce, discounts on purchases and margins decrease, and vice versa. Therefore, La Farga has engaged in hedging for years, which minimises the effect of volatile copper prices on the bottom line.

Savings on the cost of purchasing raw materials obtained through recycling technology is partly countered by the increased costs in refining and smelting scrap rather than cathode. However, as a whole, the final cost of producing thermal wire rods was significantly lower than the cost of producing electrolytic wire rods [71]. The manufacturing of wire rods using scrap, using thermal refining, afforded La Farga an immediate competitive advantage on costs and a considerable increase in market share. The continued investment in R & D to perfect the later-patented Cosmelt Process, improve the quality of the product and reduce production and environmental costs have led to the company being the leading manufacturer of semi-finished copper products in southern Europe and a world leader in recycling technology [83]. At the official launch of the joint venture SDI La Farga, in Indiana, the president of Steel Dynamics, Mark Millet, stated that the goal of SDI La Farga matched the goal of Steel Dynamics: to be the company with the lowest costs in all its business segments [93].

In general, the cost of the raw material makes up the main part of the total unit product cost, and consequently, the processing margin is small and economies in purchasing and efficiency become key competitive variables. Moreover, the transport cost of such a heavy, bulky good is also high. In the sector, it is thought that the market range of a company is limited to a radius of 1500 km because selling outside of this area would have an excessive impact on transport costs. In this sense, the location of La Farga in Central Catalonia has played in its favour, due to the fact that “66% of Spanish production of copper wire is concentrated in Catalonia, and that manufacturers of electrical conductors generate a considerable amount of scrap” [59] (p. 129).

## 5. Discussion

### 5.1. Sustainability and Value Creation

This case study analyses the business model of La Farga from a sustainability and circular economy point of view. Sustainability is underpinned by three pillars: economic viability; the viability of the product; and environmental, social and corporate governance (ESG) [18,19]. First, the company has been able to combine a balanced financial position with continuous investment in perfecting and exploiting the copper-recycling technology process, which has become its core business. Secondly, La Farga has achieved a viable product through the development and introduction of a range of products manufactured from scrap that, despite having a traditionally limited market, are suitable for satisfying the needs of particular client segments. Meanwhile, the company has maintained the manufacturing, commercialisation and innovation of products produced from mined copper, which has enabled the company to cover market segments that do not yet accept recycled products. Therefore, due to the development of products derived from recycled copper, the circularity of the business model has increased [34,37]. Nonetheless, the circularity has been partial and the increase progressive.

Third, an analysis of the company’s ESG variables reveals a favourable progression of environmental, social and corporate governance indicators. The certifications of integrated quality, environmental and health and safety management systems and the impact of the product throughout its life cycle vouch for the company’s progress in terms of sustainability and continuous improvement of the circular business model [3,18,19]. The environmental impact of manufacturing using scrap copper, through the patented Cosmelt process, is much lower than the environmental impact of manufacturing using mined copper: lower SO<sub>2</sub> and CO<sub>2</sub> emissions, less ozone layer depletion, lower water consumption and less fossil fuel depletion. Therefore, the company’s strategy is in line with the 2030 Agenda

for Sustainable Development and the European Green Deal, which seeks to extend the circular economy all over Europe [20]. Among the current environmental challenges of the company are identifying the carbon footprint, as well as reducing the consumption of gas during the recycling process of copper, with the aid of a Next-Generation EU project.

In regard to the company's social impact, some human capital indicators, such as the number of employees, high workforce stability and low workforce turnover, demonstrate the creation of lasting employment. The implementation of personnel policies that pursue equality, work-life balance, training, diversity and flexibility, bring to light the company's efforts to improve the quality of employment. In particular, the company takes extreme precautions in occupational health and safety, as shown by the OHSAS 18001 safety management and occupational health standard. Furthermore, the impact of the company takes place on the local surroundings since the vast majority of employees and directors are from the region of Osona. On the other hand, the Foundation La Farga also has a positive effect on the local community by means of donations, sponsorship, collaborations and grants and through the educational tasks carried out by the Copper Museum.

In essence, this research highlights that La Farga has a high ESG score, as demonstrated by its obtaining the management system certifications. Moreover, this study leaves a record of its continuous improvement and road map to achieve the disclosure of the remaining 33% of information, especially in terms of social capital and corporate governance. The detailed environmental and social information published over the last few years stands out and is in line with Directive 2014/95/UE and the future 2021 Directive on sustainability, which will deliver new initiatives to improve the transparency of organisations.

On the other hand, the way in which a company creates, delivers and captures value represents its business model [49]. Various studies highlight the importance of an analysis of value added in business management [39,41,42]. In general, the percentage of value generated by the subsidiaries of La Farga is low. Only La Farga Intec, a service subsidiary focused on knowledge transfer, has a high proportion of value added, due to lower supply costs. Globally, the value generated by La Farga Yourcoppersolutions represents 4% of turnover. The bulk of the value is shared equally between employee remuneration and benefits and operating costs, and 10% is allocated to capital providers. Therefore, although the generated value added is low, its later distribution allows the company to remunerate its employees, one of the fundamental pillars of the company; bear the operating costs, generated during the copper recycling production process; pay interest to the financial sector, for the use of outside funds and ultimately assure the financial viability of the company.

### *5.2. Circular Business Model*

The contribution of La Farga to the Circular Economy is significant. In the first place, producing thousands of tons of copper using scrap copper instead of mined copper conserves natural resources by limiting the mining of finite resources. At the same time, due to proper waste management and recycling of scrap metal (which mainly contains copper, but also other materials), it cleans the environment of potentially contaminating substances. In the second place, the invention of the revolutionary process Cosmelt, and its continuous improvement through R & D, represents an important contribution to copper-recycling technology. In the third place, the company has transferred patented recycling technology to more than 30 plants around the world, which in turn helps preserve natural capital and a cleaner environment. In the fourth place, La Farga indirectly fosters the Circular Economy in other ways: by collaborating with clients to help them adopt products manufactured from recycled copper as a raw material; by stimulating suppliers to maintain a steady supply of scrap; by cooperating with machinery manufacturers to improve recycling technology and by investigating alongside universities to improve the technical performance of recycled copper. Finally, the Copper Museum plays the role of educating and spreading awareness of the value of copper in the Circular Economy.

Of the six actions to move towards the circular economy in the ReSOLVE framework [44], La Farga mainly puts the actions “optimise” and “loop” into practice. Regarding optimisation, for example, through continuous R & D efforts, the company has improved the properties of copper from scrap: reducing the difference in purity to three thousandths, compared to mined copper (99.6% versus 99.9%). The company claims to be working to reduce this difference even more! Regarding loop action, the company recycles tonnes of scrap copper and transforms it into higher-quality material: in other words, it carries out upcycling, which results in a circular, “cradle-to-cradle” flow of resources [46].

Table 11 compares the “recycling circular economy business model” pattern proposed by Lüdeke-Freund et al. [5] (p. 51) with the business model of La Farga. Although, broadly speaking, the configuration of the design of the recycling pattern captures the circular business model of La Farga reasonably well, some design options of the respective morphological boxes diverge, which results in a type of variant in the recycling pattern. First, in the case of the take-back management of scrap as service, value delivery process and value creation process options, La Farga only provides this service for welding wire: outside scrap dealers perform this task for other products. The existence of the specialised scrap dealer sector, a traditional and consolidated sector, probably makes it more efficient to purchase scrap, in general, than for the company to collect it. Second, the target customers of La Farga are B2B customers, as described in the recycling pattern; however, although clients are becoming more aware of environmental conservation, clients of the company can traditionally be described as “cost-conscious customers” rather than “green customers”. Third, in terms of partners and stakeholders, although suppliers of raw material are essential for the business, other associations have also been key for the development of La Farga, such as machinery manufacturers, research centres and universities. Additionally, although recycling (upcycling) waste is undoubtedly a key value creation process, designing products and materials and in general, R & D activity, are also key activities; likewise, a series of intangible resources such as know-how, organisational culture, patents, homologations and certifications are fundamental.

**Table 11.** Contrast between the recycling pattern [5] and La Farga’s circular business models.

BM Dimensions		Lüdeke-Freund et al. [5] Design Options	La Farga Design Options	Comments
Value proposition	Products	Products based on recycled waste   Reusable or recyclable production inputs	Wire rod, drawn wire, welding wire, tube, railway cable, earthing strands, special cables, overhead lines, billets	Portfolio of copper products produced from scrap
	Services	Take-back management   Waste handling, processing	Recovery service, recycling technology transfer, technical support service, Copper Museum	Take-back management and waste handling only provided for welding wire; scrap dealers perform this task for other products
Value delivery	Target customers	Green customers   B2B customers	Electricity market, cable manufacturers, packaging manufacturers, sanitary water installers, governmental bodies, installers, railway sector, electricity distribution sector, tube manufacturers, new foundries, tourists, schools	B2B customers and cost-conscious customers. Green customers are still a minority
	Value delivery processes	Connecting suppliers and customers   Providing used products, components, materials or waste   Taking back used products, components, materials or waste	Owned distribution channels: Vicente Torns Distribution, Vicente Torns Distribution France, La Farga Tub France, La Farga Limited and external channels: warehouses. Coordinated structure to dialogue with clients: project “Value for the client”	Partial vertical integration into distribution   Taking back used waste only provided for welding wire

Table 11. Cont.

BM Dimensions		Lüdeke-Freund et al. [5] Design Options	La Farga Design Options	Comments
Value creation	Partners and stakeholders	Collectors of products, components, materials, waste	Machinery manufacturers: Continuous Properzi, Danieli. Research centres and universities. Scrap dealers. Cathode suppliers. Joint ventures: Steel Dynamics, Ganzhou Jiangwu	Open innovation
	Value creation processes	Recycling of products, components, materials, waste   Upgrading or upcycling of products, components, materials, waste   Taking back or recapturing products, components, materials, waste   Winning back base materials	Recycling of scrap. Upcycling of scrap. Taking back some used products (welding wire)   Designing products and materials (R & D)	Intangible key resources: know-how, patents, homologations, certifications
Value capture	Revenues	Additional product revenues	Approximately, half of the revenues come from sales of products produced from scrap. Royalties	Strong pressure from customers on the price of products produced from scrap. Low appreciation by the market. Copper Museum, financially loss-making
	Costs	Waste handling, processing   Resource inputs   Transportation, logistics	Resource inputs. Transportation, logistics. Waste processing. Labor	Economies in the purchase of materials. Additional cost for scrap refining. Technical efficiency

In terms of innovation of the circular business model, of the four types of innovation described by Geissdoerfer et al. [10], La Farga has primarily implemented the “circular business model transformation”. In effect, over time, the company has continuously modified components of its circular business model: new products, services, client segments, value creation processes, partners, etc. Some of the innovations have been radical, such as the revolutionary process of using continuing casting to manufacture wire rods from recycled copper, whereas others have been incremental, such as the reduction of the difference in purity between mined copper and recycled copper. Secondly, La Farga has followed the “circular business model diversification”. Indeed, in the international joint ventures SDI La Farga and Ganzhou Jiangwu, La Farga has developed new business models that incorporate strategies and resources from the organisation. In the third place, La Farga has contributed to the “circular start-ups” type of circular business model innovation. Effectively, without sharing ownership, it has transferred patented copper-recycling technology and provided technical support services for the creation of more than 30 new circular business models.

### 5.3. Enablers and Barriers

Various factors have driven La Farga to adopt the circular economy. Practically, all the types of enablers listed by Tura et al. [54] are among the reasons that have led the company to make recycling its core business, such as environmental: the company acts responsibly and strives to avoid negative environmental impact; economic: savings in the costs of purchasing raw material, additional sources of income, making a profit, developing new businesses, innovation and synergy opportunities; social: increase in internationalisation and awareness of sustainability needs; technological: availability of new technologies and the potential to improve existing operations; supply chain: lower dependence on resources, improved options to manage high and volatile prices; open collaboration opportunities, management of reverse networks and organisational: possibilities of differentiating and

strengthening the company's brand, increased understanding of the demands of sustainability, integration of circularity into the strategy and goals of the company.

However, despite the multiple incentives that have led La Farga to not only adopting the circular economy but also to becoming a leading name in copper-recycling technology, the company has not ceased its production of products using mined copper. On the contrary, in 2007, it set up the subsidiary La Farga Rod to manufacture electrolytic copper wire. Since then, the income from the sales of products manufactured using mined copper has grown proportionally more than the sales of products manufactured using scrap copper. Although the company firmly maintains a strategy focused on recycling, if it only manufactured products using scrap, the growth and development of the company would be hindered due to the presence of various barriers.

The relative importance of the different types of barriers faced by the company in implementing the circular economy is consistent, to a large extent, with the findings of Kirchherr et al. [53]: cultural barriers are higher and, contrary to popular belief, technological barriers are less important. Market and regulatory barriers are of intermediate importance. In effect, the main barrier is the lack of awareness or willingness of clients to engage in the circular economy, particularly among purchasing and production departments, but not sustainability departments. Traditionally, La Farga has found that its customers prefer "new products"; they demand lower prices for recycled products, or they resist adapting their production process to use recycled copper as a raw material. Admittedly, for cable manufacturers, for example, to use recycled copper as an input, they would need to carry out certain modifications to their machinery; but their output would still be of the same quality. Nonetheless, the company has observed an increase in customers' responsiveness, probably due to the fact that manufacturing with recycled material offers customers a way to defend the environmental sustainability of their own product.

Undoubtedly, there are technological barriers. For example, the automotive sector demands cables that offer both high conductivity and are, at the same time, very thin. In order to achieve these properties, the copper needs to be 99.99% pure, which can nowadays only be manufactured using mined copper and not scrap (99.96%). Yet, in other instances, the barriers that impede the use of recycled copper are regulatory and not technological. In the railway sector, governmental agencies state that catenary cables must be manufactured using electrolytic copper ETP1, which can only be obtained from mined copper and not recycled copper. However, La Farga is aware that catenary cables produced from scrap would be perfectly valid. If the regulations allowed the use of recycled copper, the railway sector, which supposedly provides a sustainable mode of transport, could increase its own circularity because it would make it possible to recycle materials at the end of their useful life. Ultimately, the analysis of the barriers highlights the difficulty in implementing a completely circular business model. Even in the case of a company that is firmly orientated towards recycling, the existence of barriers makes combining the linear and circular models necessary in order to remain competitive. It also highlights that a company's progress towards circularity is gradual, not immediate.

## 6. Conclusions

This investigation of La Farga constitutes a descriptive study on the circular economy useful for business, education and policy purposes. The case study dissects the strategy of a company that is a world reference in recycling technology in order to show the application of basic concepts of sustainability and the circular economy: measuring the progress of economic, social, environmental and good governance sustainability; calculating the added value generated and distributed by the company; analysing the circularity traits present in the value proposal, delivery, creation and capture; characterising the circular business model of La Farga as a variant of the recycling pattern [5]; examining the type of circular business model innovation followed by the company [10] and exploring the enablers that

have motivated the company to adopt the circular economy [54] and the barriers that have hindered the implementation of a completely circular business model [53].

Finally, there are some limitations to this case study, which could give rise to future investigation. On the one hand, the approach to this investigation has been managerial and not technical, and consequently, we have omitted issues relevant to material science, process engineering, environmental sciences, etc. On the other hand, despite the length of the study, some components of the circular business model of La Farga could have been studied in greater detail. For example, value proposal could have been analysed according to the design configurations of Ranta et al. [101]; or the collaborative partnerships established with welding wire clients, resulting from the take-back management service, could have been analysed in light of the taxonomy of industrial symbiosis business models of Fraccascia, Giannoccaro et al. [102]. Furthermore, we have not explicitly analysed the multiple interlinkages between the components of the circular business model [103]. Additionally, the analysis of La Farga, a leading name in the management of a family owned business [104,105], has highlighted the fact that being a family owned business has favourably influenced its sustainability. However, we have not explored the relationship between the family owned business and sustainability.

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## Appendix A. Timeline of the Company

- 1808. Francesc Lacambra i Pont establishes a small foundry near the port of Barcelona.
- 1844. Francesc Lacambra becomes one of the main copper suppliers of the Mint of Barcelona.
- 1852. Relocation to Les Masies de Voltregà, to build a forge by the River Ter.
- 1853. Start of manufacturing copper sheets used to line the hulls of the ships that travelled to the American colonies.
- 1859. The Lacambra family builds and leases a spinning and cotton mill next to La Farga.
- 1870. The founder, Francesc Lacambra Pont, dies. His sons, Ferran and Joan Lacambra Pujadas, continue the business under the name “Hijos de Francisco Lacambra” (Sons of Francisco Lacambra”).
- 1877. The substitution of sailboats for steamboats causes manufacturing to be re-focused on the production of sheets for domestic steam boilers and steam train engines.
- 1888. La Farga receives an award from the Barcelona Universal Exposition.
- 1898. The foundry in La Barceloneta closes. The warehouses are relocated to Bailén Street in Barcelona.
- 1913. Start of manufacturing of wire rods for electric cables, under the management of Josep Lacambra Saborit, son of Ferran Lacambra.
- 1914. During the First World War, the company enjoyed a great financial boom.
- 1921. Francesc Lacambra Lacambra, son of Josep Lacambra Saborit, inherits the company.
- 1927. King Alfonso XIII visits La Farga and bestows the title of count on Francesc Lacambra Lacambra.
- 1933. Francesc Lacambra Lacambra, the husband of Teresa Estany Jimena, dies.

1936. The Spanish Civil War (1936–1939) breaks out, the company is collectivised and production is used for military purposes.
1939. The war ends, the company returns to the family Lacambra, under the management first of Ramón Estany and then of Francisco José Lacambra Estany.
1950. During the 1950s, the Lacambra family sponsors numerous social and sporting activities.
1952. Acquisition of a bar and wire rod rolling mill, which increases production capacity.
1959. Between 1959 and 1975, the company sees its greatest growth.
1976. Acquisition of a semi-automatic sheet mill.
1979. Severe crisis. The owners Teresa Estany and Maria Josefa Lacambra entrust the management of the company to the law firm Castejón y Asociados.
1980. Oriol Guixà presents the report “Productive study and valuation of the factory”. The Lacambra family no longer owns the company. Incorporation of La Farga Lacambra, S.A.
1982. The company Francisco Lacambra Lacambra presents a project to the Copper Industries Reconversion Plan of the Spanish Government.
1983. Francesc Lacambra Estany dies. His sister, María Josefa, and his mother, Teresa, inherit the factory.
1984. The reconversion plan presented by the Francisco Lacambra company is approved. The company La Farga Lacambra, S.A. buys the factory from the Francisco Lacambra Lacambra company and takes over the debts with creditors.
1985. Oriol Guixà Arderiu, an industrial and aeronautics engineer, is appointed managing director.
1986. La Farga launches the first continuous casting process using recycled copper in the world.
1987. A new continuous cathode-fusing furnace is installed.
1988. Installation of a new wire drawing section. A cooperation agreement with Continuous-Properzi is signed for the sale of technology.
1989. The wire-drawing section is extended.
1990. Entry into the welding wire for the metal-packaging market (Joinfil).
1992. Construction of a new plant for the production of copper tubes.
1993. La Farga Lacambra, S.A. opens a proceeding for suspension of payments.
1995. The court in Vic approves an agreement reached with the creditors and lifts the suspension of payments.
1998. The English company British Company Delta buys 50% of the tube plant and establishes Tertub. La Farga Lacambra, S.A. settles its suspension of payments.
2000. The foundry is overhauled: the Cosmelt Process is launched.
2001. A family protocol is agreed upon.
2003. Vicenç Fisas and Oriol Guixà set up as equal partners the parent company Corporació Metal·lúrgica Catalana, S.L., which acquires La Farga Lacambra, S.A.
2004. The Fundació La Farga is created.
2005. Return to the railway market with a new range of products for electrification.
2006. The La Farga Group brand is created, a family owned holding company.
2007. La Farga Rod is created, to manufacture electrolytic copper wire.
2008. Two-hundredth anniversary of La Farga. The Copper Museum is opened.
2009. La Farga Intec is born. Joinfil Ecocopper is launched. La Farga Advanced Materials is created.
2010. Ganzhou Jiangwu La Farga High-Speed Railway Copper Materials Co. Ltd. is launched in China. The company creates its own research centre at the Autonomous University of Barcelona.
2011. La Farga Tub France is set up in France.
2012. SDI La Farga is launched in the United States. The La Farga Yourcoppersolutions brand is created.

2013. La Farga Limited opens in the United Kingdom. The Dx3 technology is presented. The collaboration agreement with Continuous-Properzi is terminated.
2014. Divestment in Ganzhou Jiangwu La Farga. Launch of the CAC conductor.
2015. Launch of the Transmission programme.
2016. Vicente Fisas Comella (1927–2016) dies: businessman, lawyer and co-founder of La Farga.
2017. Inka Guixà Fisas is named managing director of La Farga Group. A deal is signed with Danieli for the sale of technology.
2018. The group's companies are unified under a single company: La Farga Yourcoppersolutions, S.A.
2019. A 15 million euro investment in a new copper continuous casting line, which increases production capacity by 33%.

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