How labour-intensive is the circular economy? A policy-oriented structural analysis of the repair, reuse and recycling activities in the European Union [1]

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Abstract

The socio-economic structural conditions for the transition towards a circular economy (CE) are currently little explored, as most of the research on the subject is concerned with its technical and organizational aspects. In the European Union, the few studies addressing the matter focus mainly on the estimation of GDP growth and job creation potentially resulting from an increase in the share of certain "circular activities" (CA). The basic assumption is that these CA are labour-intensive, and thus the expected job losses resulting from the paradigm shift would be offset by the overall gains. However, significant structural differences in the economic characteristics of the sectors concerned suggest that their development may have dissimilar socio-economic implications, while their promotion would not necessarily require the same kind of policy instruments. This paper aims to address these issues by analysing the current sectoral structure, main economic features and recent evolution of the CA in the European Union.The focus ison repair, reuse and recycling sectors, as a limited yet representative subset of all the CA which are currently bound and constrained *within the predominant linear economy. We make use of economic data from the 24 productive branches that make up these sectors according to Eurostat. Results show that, although the studied CA are on the whole more labour-intensive than the average, there are significant differences between repair and reuse, on the one hand, and recycling, on the other.Besides, employment concentrates in low-wage labour-intensive CA, suggesting that more attention should be paid to improving competitiveness and working conditions in activities such as repair and reuse which, given their higher labour intensity and lower demand for natural resources, are by definition both ecological and inclusive. Also, significant differences in the structural characteristics of the activities under analysis imply the need for targeted policy instruments tailored to the specificities of each of the various CE sub-sectors.* **Key words**

Circular economy / circular activities / sectoral structure / capital intensity / labour productivity / labour intensity.

1. Introduction

As a relatively novel conceptualization for a new productive paradigm, circular economy (CE) is still subject to quite different delimitations depending on each author and/or institution. It could be defined, in a rather eclectic way, as an alternative to the current linear economic model based on extraction-production-use-disposal, consisting of a transition towards a regenerative system of production and consumption designed to preserve the value of products, components, materials and energy for as long as possible, in order to minimize the ecological impact of human

[1] This study was mostly conducted before 31 January 2020, and thus applies to the EU-28, i.e. European Union including the United Kingdom.

economic activity (Ellen MacArthur Foundation, 2015; Hobson, 2016; Kirchherr et al., 2017; Korhonen et al., 2018a; Stahel, 2006). The prominence achieved by the concept and the efforts to disseminate its practices at present are a response to the alarming environmental situation resulting from two centuries of economic growth based on unrestricted resource extraction and production of waste and emissions, without taking into consideration the natural regeneration capacity of the biosphere. Evidence indicates that, if current levels of resource consumption are maintained, the equivalent of three planets Earth will be necessary by 2050 to meet the material needs of a world population of over 9 billion people (United Nations, 2017). Moreover, the average global temperature is projected to increase by at least 1.5ºC, if by 2050 greenhouse gas emissions are not reduced between a 65% and 90% with respect to those of 2010, resulting in severe climate effects and irreversible ecological damage (IPCC, 2018). This critical situation at the environmental level is also framed in a conflicting socio-economic context, in which the effects of the 2008 international financial crisis still prevail and the strong inequalities among territories continue to deepen (Stiglitz, 2019; Tooze, 2019; Vence, 2013). Within the European Union, the gap between the countries of the North and the South remains wide, as reflected in the higher levels of unemployment and income inequality in the latter.

A number of reports and studies point to the CE as a potential source of sustainable job creation, thus positing it as an innovative and inclusive solution to the European Union's most pressing environmental and socialissues (Cambridge Econometrics et al., 2018; Friends of the Earth, 2010; Morgan and Mitchell, 2015; Wijkman and Skanberg, 2015). In particular, job creation is often presented as a positive externality of a transition to the CE which is focused primarily on resource efficiency and recycling and, to a minor extent, on waste reduction. Less attention is paid, however, to the fact that a number of activities which are also considered to be intrinsically circular due to their direct involvement on value preservation and life extension of goods (e.g. reuse, repair, remanufacturing, etc) actually make a twofold contribution to CE precisely *because* they are labour-intensive rather than based on resource extraction or new capital goods production (Deloitte, 2016; Llorente-González and Vence, 2019; Stahel, 2019, 2006).

Among the economic activities that are mainly devoted to the preservation of the value of goods and materials, and thus generally regarded as key in the transition towards a CE, the European Commission has categorized the repair, reuse and recycling sectors as "circular" activities in the

first CE Action Plan and in the Monitoring Framework for CE (European Commission, 2018a, 2015). The contribution of CE to social welfare in the EU is therefore estimated on the basis of the potential for job creation of a rather heterogeneous set of activities, which ranges from waste collection, materials recovery and recycling, to repair of all kinds of goods - from airplanes and precision equipment to clothing and footwear - and retailing of second-hand items. In this sense, the degree and type of the "circular" character of these activities is far from homogeneous. Some authors have pointed out the existence of fundamental and hierarchical differences between the various circular models or activities, as is the case of the distinction between the R's (reuse, repair, remanufacturing, etc), activities that preserve the value of the integrity of manufactured objects and their parts, as opposed to the D's (de-polymerise, de-alloy, de-vulcanise, etc) which focus only on their stocks of atoms and molecules (Stahel, 2019); the hierarchy of value retention options (ROs), from those that keep goods and components in short cycles closer to the users and to their original functionality (refuse, reuse, repair), to those less desirable linked to the longest loops, in which the original function of the products is completely lost (recycling, recovery, re-mine)(Reike et al., 2018); and the classification of circular strategies according to the level of entropy of the materials involved, distinguishing between those linked to the states of higher order (products – reuse), medium order (parts – repair, refurbishment, remanufacture) and to the most dispersed ones (particles – recycling, remining) (Blomsma and Tennant, 2020). Such kind of categorizations is of great relevance to public policy development for the promotion of CE, as they allow priorities to be established and support the decision-making process. However, there is still a lack of attention to the economic structural heterogeneities that exist between the different CA which, on the one hand, lead to different socio-economic impacts, and on the other hand condition the specific type of public policies that are more appropriate to promote each of them.

Consequently, the present study aims to validate the hypothesis regarding the relatively higher labour intensity of the set of activities identified as "circular" or "CE related" by the European Commission, and to explore the specific economic structuralcharacteristics of the different sub-groups of activities that it comprises. . To do so, we analyze the relative share, evolution and main economic features of the 24 productive activities that, according to Eurostat, make up the

repair, reuse and recycling sectors in the European Union, clustered according to two relevant structural dimensions, labour intensity and average labour productivity.

We are aware that taking the share of repair, reuse and recycling activities as a proxy to the general levels of "circularity" of an economy, as the European Commission suggests (European Commission, 2018b), can be a problematic assumption, as it fails to account for the degree of propagation of a variety of circular economy business models (CEBMs) and practices that are cross-cutting to all economic sectors (Horbach et al., 2015; Planing, 2015; Urbinati et al., 2017; Weetman, 2016). But, unfortunately, for the time being there is no statistical information on the real diffusion of CEBMs across the EU countries that allows for an approach to measure "circular" employment other than sector-based. This is mainly due to the many practical limitations that currently exist to consistently discern the impact of CE-related initiatives on the productive activities in which value preservation is not the ultimate goal, but an alternative means to "capture value", such as cost/risk reduction, compliance with environmental regulations, enhanced customer loyalty, etc (Bocken et al., 2016; Govindan and Hasanagic, 2018). In particular, the vast majority of the available data sources and indicators, as well as the most widely used classifications of economic activities, are based on the logic of value creation rather than on the preservation of physical stocks of resources (Franklin-Johnson et al., 2016; Llorente-González and Vence, 2019; Parchomenko et al., 2019). Thus, we acknowledge that this scarcity of relevant data reveals the need to further complement the analysis by taking into account the various circular initiatives that can be applied in virtually all economic activities, such as eco-design, eco-innovation, industrial symbiosis, product-service-systems and so on (Llorente-González and Vence, 2019; Vence and Pereira, 2019).

The next section will provide a brief review of the existing literature addressing the socio-economic and labour dimensions of CE, with particular emphasis on EU-focused studies. The third section will be devoted to the presentation of the data source and methodology. The fourth and fifth sections present the results and outline the main findings of this study, deriving public policy recommendations and relevant issues for future research and discussion.

2. Current approaches to the structural, socio-economic and labour dimensions of the circular economy

Even though the concept of CE emerged originally out of concern for the ecological limits of human economic activity, thus involving the interaction between the economic, social and natural spheres of human existence, most of the CE-related literature focus nowadays on its most technical aspects, neglecting its multiple and complex socio-economic conditions and implications (Gregson et al., 2015; Hobson, 2016; Hobson and Lynch, 2016; Kirchherr et al., 2017; Korhonen et al., 2018a, 2018b; Murray et al., 2017; Reike et al., 2018). A basic bibliometric exercise is enough to notice the contrast between the abundance of research on the subject related to engineering, industrial organization or supply chain management, and the relatively small amount of scientific studies from the social sciences. Particularly paradoxical is the scant attention given to CE from the field of economic analysis, with few exceptions such as the introduction of the concept of CE rebound (Zink and Geyer, 2017). This research gap is further accentuated when considering relevant macroeconomic dimensions, such as the economic structure of the diverse CE-related activities and their socio-economic implications.

CE is presented in mainstream literature as the result of a significant but non-problematic change in production and consumption practices towards greater relative efficiency in the use of resources and exploitation of waste, led by environmentally aware entrepreneurs and consumers, and encouraged mainly by market-oriented policies (Ellen MacArthur Foundation, 2015; Ellen MacArthur Foundation et al., 2015; World Economic Forum et al., 2014). The socio-economic dimension of the resulting productive transformation is rarely addressed (Gregson et al., 2015; Hobson and Lynch, 2016; Lazarevic and Valve, 2017; Nogueira López, 2019), while little attention is paid to the limitations and constraints imposed by the current economic structure, despite it being the result of two centuries of development driven by continuous accumulation sustained on a linear logic. According to Machlup (1991, p.76) the economic structure generally refers to the "different arrangements of productive activity in the economy, especially to different distributions of productive factors among various sectors of the economy"(Machlup, 1991), which are reflected in the relative weight that each sector have in terms of the basic macro-economic aggregates, such as output, value added, investment, employment, etc (Silva and Teixeira, 2008). The differences in technology, productivity, capital and labour intensity between the various sectors that compose the economic structure determine their specific and diverse dynamics, leading to the process of structural change (Cimoli et al., 2005). This process, inevitable in a globalized world economy and a prerequisite for economic development, is not

necessarily virtuous (ECLAC, 2014). When the evolution of the different sectors is uncoordinated, unbalanced, biased or disconnected from global technological paradigm shifts, it can lead to the perpetuation of difficulties in the generation of technical progress and skilled and formal employment, with negative effects on welfare and income distribution (Coatz et al., 2010; ECLAC, 2014).Preventing this from happening is one of the main objectives of targeted sectoral stimulus policies which need to be based on structural economic analysis in order to account for the specific conditions and needs of each sector (Cimoli et al., 2017; Pianta, 2017).

The scarce literature that deals in some way with the structural and socio-economic implications of the transition to CE focuses on the potential gains from CE in terms of GDP and employment, and consist mostly of reports from public institutions and non-governmental bodies devoted to the promotion of the concept (Circle Economy and EHORE, 2017; Ellen MacArthur Foundation et al., 2015; European Commission, 2018c; European Environmental Agency, 2016; Morgan and Mitchell, 2015). They usually rely on the basicassumption that the CE sectors or activities, whatever they may be, tend to be in general more labour-intensive, so even if the paradigm shift implies job losses in some areas, these would naturally be offset by the overall gains. The selection of "CE-related" sectors varies considerably amongst the different studies, which is not surprising given the current lack of a consensus regarding the conceptual definition of CE (Kirchherr et al., 2017; Korhonen et al., 2018b; Murray et al., 2017; Reike et al., 2018). Some of them focus on certain economic activities, such as second-hand retail, waste management, recycling, repair and renting (Deloitte, 2016; European Commission, 2018c; Mitchell, 2015; Morgan and Mitchell, 2015). Others consider certain jobs as circular (such as solar panel installers, recycling operators, leasing managers, etc.), so the selection of sectors is made on the basis of the presence of these kind of tasks (Circle Economy and EHORE, 2017). Finally, a few studies do not focus on certain "circular sectors" but attempt to estimate, by means of macro-econometric and input-output simulation exercises, the aggregate effects of concrete scenarios of transition towards a CE(Cambridge Econometrics et al., 2018; ILO, 2018; Wijkman and Skanberg, 2015). The results depend to a great extent on the *ad-hoc* choice of policy assumptions and change scenarios (e.g. increasing recycling rates, growth in the repair, reuse and sharing activities, increasing materials and energy efficiency, etc) (Horbach et al., 2015). In this context, the European Commission defined a set of metrics to monitor the degree of progress in the EU strategy of transition towards a CE (European Commission, 2018a). With a focus on increasing

recycling rates and promoting secondary raw material markets, the analysis of the socio-economic dimension of the transition is limited to measuring the share in the European economies of a group of sectors which are considered to be "closely related" to CE, i.e. repair, reuse and recycling activities. These activities are also regarded as "good proxies for the mainstreaming of the circular economy in other sectors" and "particularly job intensive" (European Commission, 2018b). The employment generated by these activities is thus presented as a measure of the positive social outcome of CE, even though the available data show that, at present, the participation of these sectors is higher in the countries with lower levels of economic development, as evidenced by the negative correlation between per capita GDP and the share of these activities in total employment across the EU Member States (Llorente-González and Vence, 2019).

Despite being grouped together as activities closely related to CE, or circular activities (CA), many relevant qualitative differences between the repair, reuse and recycling sectors have been outlined in the CE literature.. From a value preservation perspective, reuse and repair are generally regarded to keep products and materials for a longer time in the most "inner", "shorter" or "tighter" loops or cycles, this is, remaining closer to the users and to their original functionality, and thus becoming more desirable options than recycling in the hierarchy of value retention options (usually referred to as 'Rs') (Ellen MacArthur Foundation, 2015; Reike et al., 2018; Santamaría Arinas, 2019; Stahel, 2019, 2013). This is largely due to the fact that strategies such as reuse and repair aim to preserve resources in their lowest entropy state, i.e. the highest level of order (finished products), while recycling and recovery involve higher energy inputs by dealing with the most disperse and diffuse of the materials forms (particles and molecules) (Blomsma and Tennant, 2020).

Beyond these technical and "circularity" differences, the economic structural variety should also be considered as a relevant dimension for the set-up of circular strategies. The economic structure refers to the composition of certain basic macro-economic aggregates or magnitudes (such as output, employment, investment, etc), whose composition is assumed to vary little over time. Besides, each activity involves diverse technical and organisational capacities, requires different labour shares and skills and offers disparate working conditions, especially as they are embedded in a productive paradigm whose logic is mainly linear, profit-driven and growth-

oriented. As a result, recycling and waste separation activities are still associated in many regions with alternative survival strategies in the face of increasing inequality, unemployment and poverty (Sassen, 2010), resulting in vulnerable employment with high rates of informality, low wages and hazardous and unhealthy working conditions (Cointreau, 2006; Dauvergne and LeBaron, 2013; ILO, 2004). On the other hand, the various repair activities (e.g., repair of vehicles, household appliances or footwear) do not operate in the same way either, nor do they offer the same working conditions (ADEME et al., 2018a). Consequently, it is to be expected that both the impact on welfare, labour and income distribution, and the most appropriate policy strategies to support their development, should differ between repair, reuse and recycling sectors, due to the diverse and specific characteristics of the various recovery and preservation activities that they comprise.

3. Data source and methodology

In order to contribute to a better understanding of the socio-economic and labour implications of CE, we carried out a characterisation of the economic structure of the activities considered to be closely related to CE within the European Union. To this end, we resorted to the databases that constitute the Structural Business Statistics (SBS) compiled by Eurostat[2]. This source provides information on the main economic indicators of the European firms that comprise the so-called "business economy" sectors, i.e. those included in sections B to N plus division 95 of section S of the second revision of the statistical classification of economic activities in the European Union (NACE Rev. 2).

In particular, we studied the 24 productive activities considered in Eurostat's methodology as being related to the CE (Eurostat, 2019a), this is the branches that make up the sectors of reuse, repair and recycling. It is acknowledged that a comprehensive analysis would also require the inclusion of productive units in other economic sectors that also carry out actions related to the CE. However, due to the impediment of making an adequate identification of those productive units on the basis of the available information, we will assume, in the same line as the European Commission, that the 24 selected activities are fairly representative and allow a first

[2] Available at https://ec.europa.eu/eurostat/data/database.

253 approximation to the study of the socio-economic implications of the CE as a whole (European
254 Commission, 2018b).

255 Data was collected for the 24 branches on the number of firms, total production value (PV),
256 value added (VA), gross operating surplus (GOS), turnover (T), wages (W), gross investment in
257 tangible goods (GItg) and persons employed (L) with and without remuneration (Lw and Lnw)
258 for 2011 and 2016, as this is the longest and most recent period for which complete information
259 is available for the majority of activities. The structural analysis focus on the year 2016, and only
260 the variation between the initial and final years of the period was studied, due to the presence of
261 information gaps for some sectors in the intermediate years. In the case of retail sale of second-
262 hand goods in stores (branch G4779), data for PV, VA, W and L correspond to the year 2015, as
263 well as Lw and Lnw data for the sale, maintenance and repair of motorcycles and related parts
264 and accessories activity (G454). Data on PV, VA, GOS, T, GItg and total paid W are available in
265 million euros for each branch of activity.

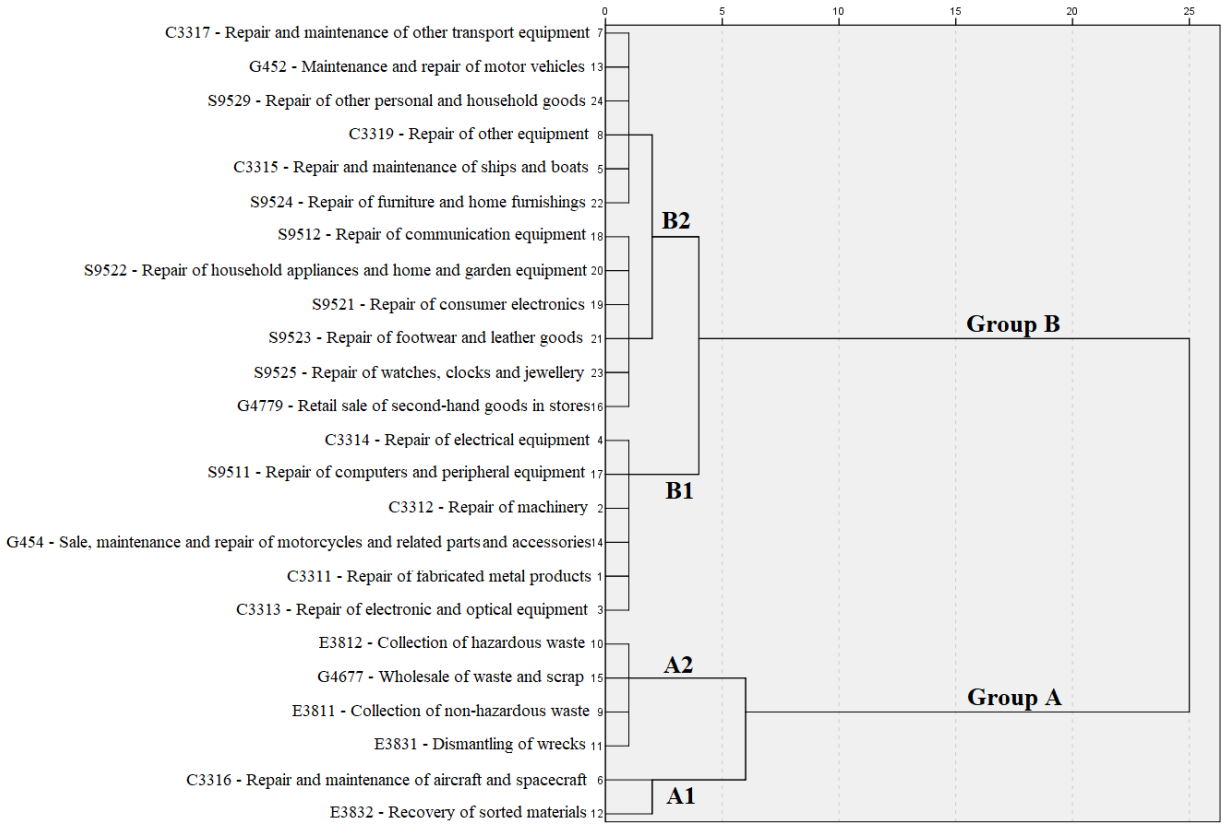
266 The SBS database considers as “persons employed with remuneration” all those who receive
267 some kind of monetary or in-kind compensation for their work, whether they are hired
268 employees, self-employed workers, students on internships, domestic workers, part-time or
269 seasonal workers, and on strike and/or on short-term leave workers, and excludes workers on
270 long-term leave, volunteers and unpaid family workers. Temporary agency workers are counted
271 as employees of the agency and not of the production unit to which they are assigned (Eurostat,
272 2019b). As mentioned previously, a distinction will be made in this study between employed
273 persons in total (L), and paid (Lw) and unpaid (Lnw) workers.

274 Indicators were then calculated on average firm size in terms of employment (L/firms) and
275 turnover (T/firms), labour productivity (VA/Lw), average remuneration (W/Lw), gross
276 investment in tangible goods per worker (GItg/Lw), share of unpaid labour in total employment
277 (Lnw/L) and gross operating surplus rate (GOS/T). The lack of information for the total of the
278 sectors prevented the composition of other relevant additional metrics, such as productivity per
279 hour worked. In consequence, per worker indicators should be taken with caution, as the average
280 length of the working day is unknown. Labour productivity and gross investment per worker
281 were calculated with respect to the number of paid workers (referred to as “employees” in the
282 SBS) and not to the total amount of persons employed (including unpaid labour). This decision

was motivated by the limitations of the data source, which lacks of information regarding the total amount of hours devoted to production by unpaid workers, the type of work journey or any other relevant indicator that could allow for a general estimation of their contribution to final output in the different "circular" activities. It should be noted, though, that the main findings of the study would not vary if these indicators were calculated in relation to all the persons employed (see Annex, Table 3). On the contrary, the unusually low levels of productivity and investment per worker obtained in some of the "circular" activities when unpaid employment is considered would actually reinforce the results. Gross investment in tangible goods per paid worker (GItg/Lw) was considered a proxy of capital intensity (and the opposite, of labour intensity). The values for VA/Lw, W/Lw and GItg/Lw of the CA are presented and analysed in relation to the average of all the economic activities (total average = 100).

The second step was to classify the 24 activities into homogeneous groups according to two economic proxy variables, reflecting labour productivity (VA/Lw) and capital/labour intensity (GItg/Lw), by means of an agglomerative hierarchical cluster analysis. This method was considered the most appropriate given the relatively small sample size, and allowed for the ex-post selection of the number of groups, depending on the level of agglomeration with a higher economic significance. Labour productivity and capital/labour intensity were standardized based on the average of all economic sectors for both variables. The relatively high value of GItg/Lw in the sector of recovery of sorted materials (E3832) motivated the use of the average-linkage between groups and Ward's methods, both of which are less susceptible to the presence of potential outliers. Thus, a total of four groups were obtained, subdivided into two main sets or ramifications (A and B) (Figure 1).

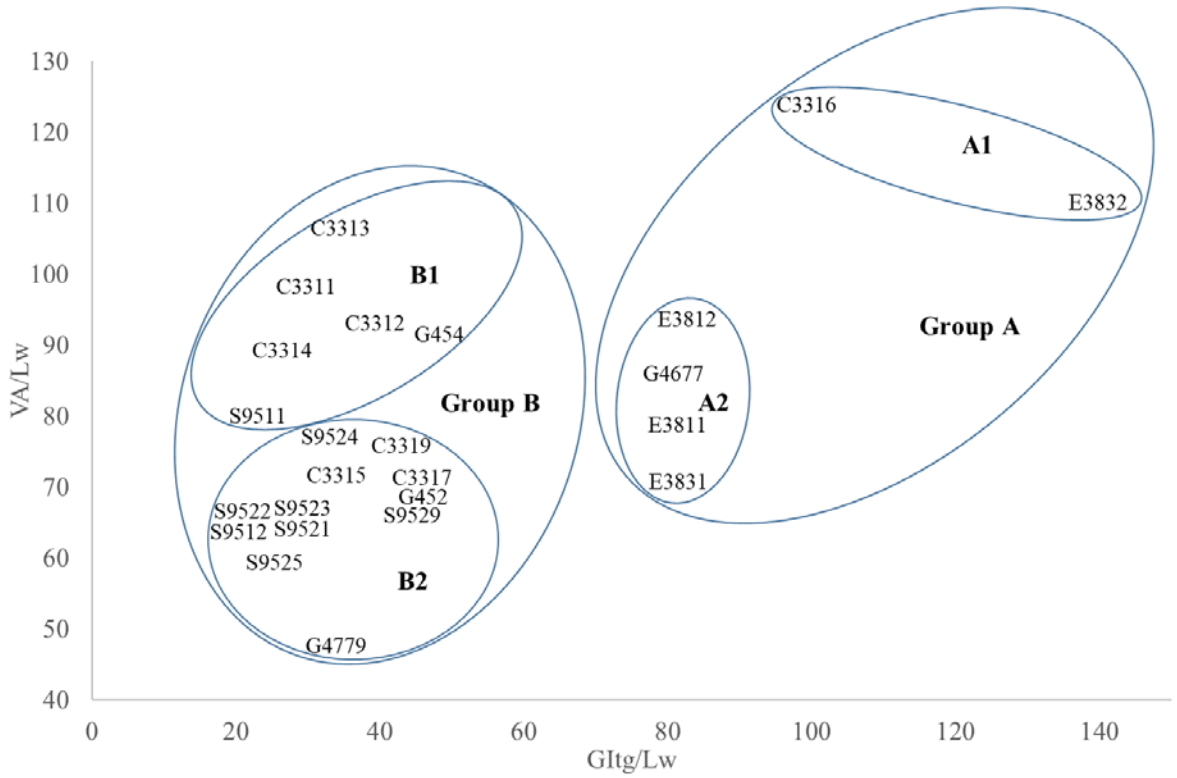
Figure 1: Dendogram of the 24 branches related to CE, grouped according to labour productivity and capital/labour intensity. Re-scaled distance cluster combination. Ward's method.



SOURCE: Own elaboration on the basis of Eurostat.

Finally, the economic interpretation of the resulting classification was assessed. In the first place, it was observed that the division between groups A and B was based mainly on differences in capital/labour intensity (higher in A, lower in B), while at least two sub-groups could be identified within each one of them, depending on labour productivity. As a result, the 24 activities were finally classified into four groups: capital intensive with high labour productivity (A1); capital intensive with medium labour productivity (A2); labour-intensive with medium-high labour productivity (B1); and labour intensive with medium-low labour productivity (B2). The graphic representation of the classification is shown in Figure 2.

Figure 2: Graphic representation of the classification of the 24 activities related to CE according to labour productivity (VA/Lw) and capital intensity (GItg/Lw). Total Economy* = 100.



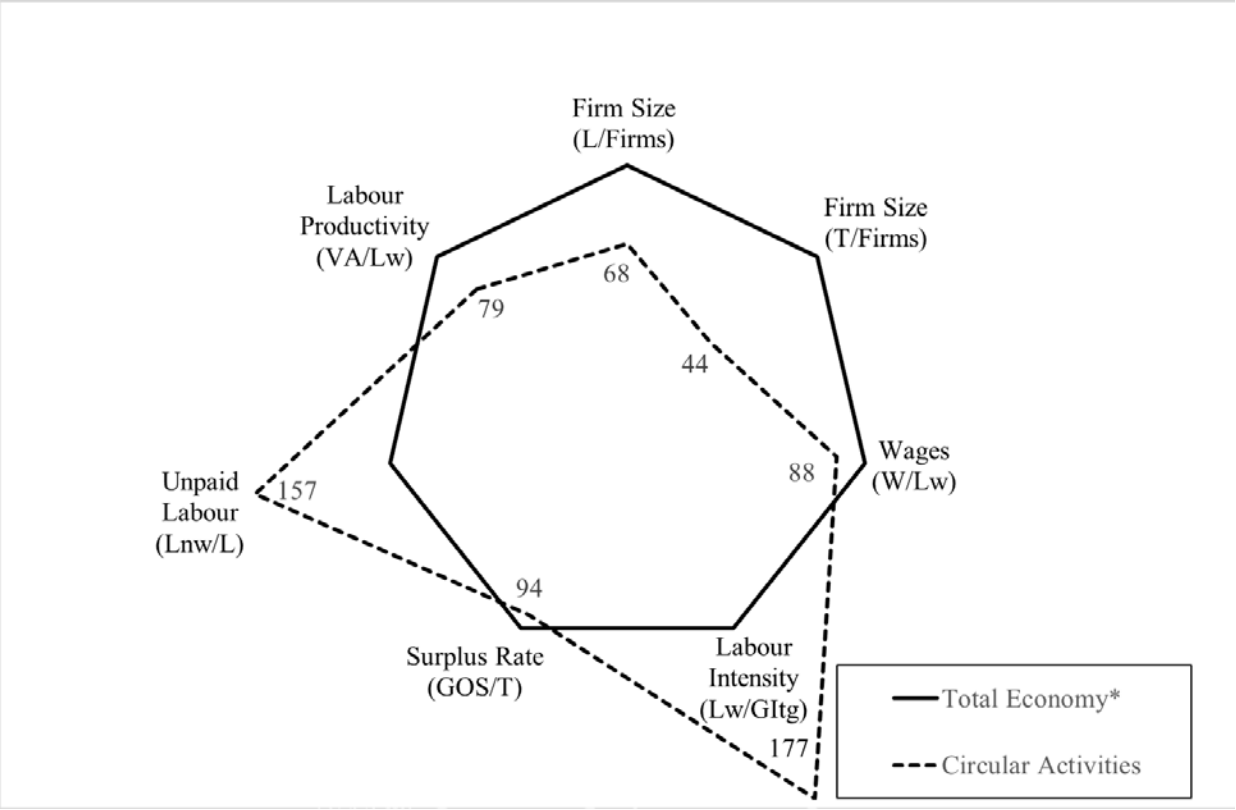
** Sectors included in Sections B to N plus Division 95 of Section S, NACE Rev. 2*

SOURCE: Own elaboration on the basis of Eurostat.

4. Results

The available data for the year 2016 indicate that more than 1 million firms operate in CE-related activities (reuse, repair and recycling) in the EU, comprising approximately 4% of the total amount of companies surveyed by Eurostat's business structure statistics. The CE sectors generated in that year more than € 350 billion in production value (1.9% of the total), nearly € 150 billion in VA (2%) and € 500 billion turnover (2.2%), of which they obtained € 51.5 billion in gross operating surplus (1.7%). They also employed over 4 million workers (2.8%), 79% of whom were remunerated whereas the remaining 21% received no payment for their work (4.4% of the total number of unpaid workers). On the other hand, the gross investment in tangible goods in these sectors only reached € 17.5 billion (1.5% of the total). Firms in CE-related activities are on average smaller, both in terms of number of persons employed and turnover per firm. Their labour productivity and their wage level are also lower than the average. In addition, labour intensity and the share of unpaid labour in total employment are more than 50% higher than those of the rest of the economic sectors (Figure 3).

Figure 3: Economic characterisation of the set of circular activities (CA). Total Economy* = 100. 2016. EU-28.

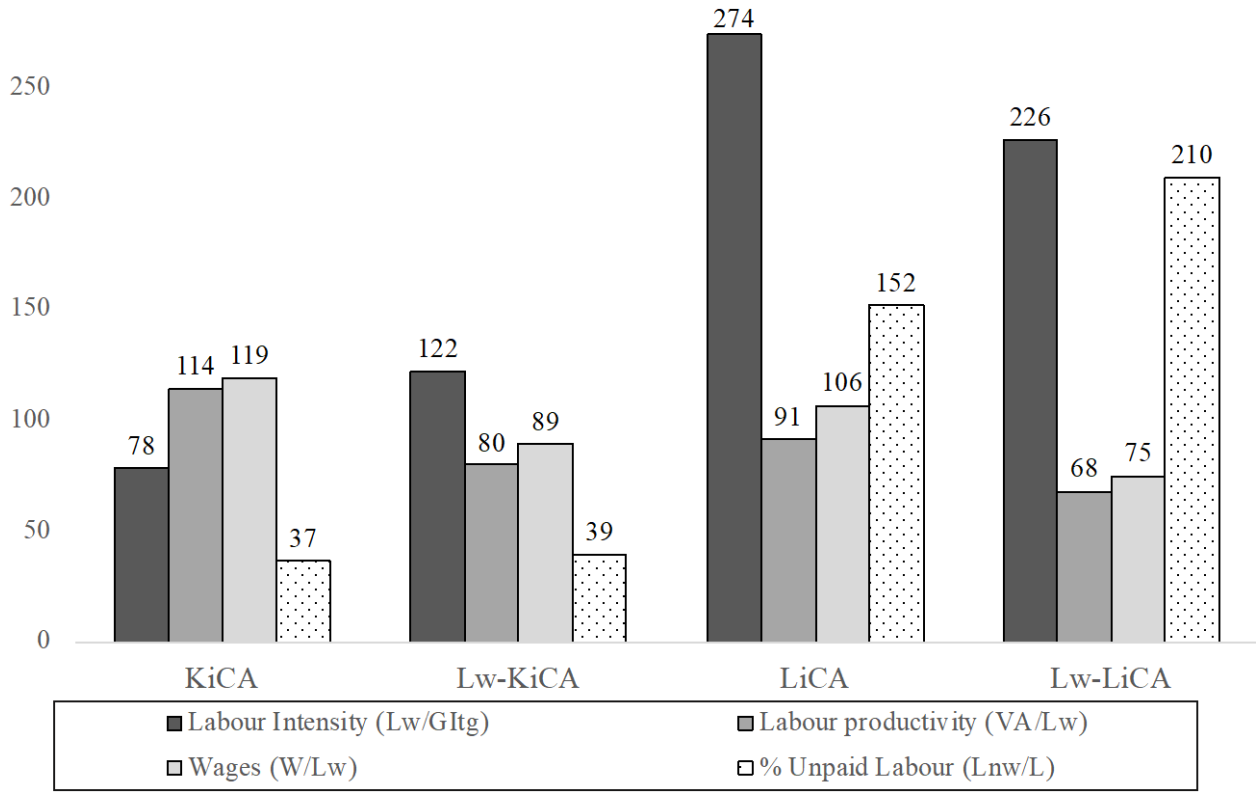


** Sectors included in Sections B to N plus Division 95 of Section S, NACE Rev. 2*

SOURCE: Own elaboration on the basis of Eurostat.

Beyond the general features of the set of CA, there are significant differences between the clusters that were derived from the analysis described in the previous section. As expected, Group A1 is well below the average of the CA (and of the total economy) in labour intensity, but presents higher labour productivity. This group also shows the highest wage levels, together with a relatively low proportion of unpaid work (Figure 4). It mainly consists of the activities of recovery of sorted materials, that is, the industrial phase of recycling, and, to a lesser extent, of the repairing and maintenance of aircraft and spacecraft sector. On account of its more salient characteristics, this group will hereafter be referred to as capital-intensive circular activities (KiCA).

Figure 4: Characterisation of circular activities (CA). By groups of activities according to capital/labour intensity and average labour productivity. Total Economy* = 100. 2016. EU-28.



** Sectors included in Sections B to N plus Division 95 of Section S, NACE Rev. 2*
SOURCE: Own elaboration on the basis of Eurostat.

Group A2 comprises the non-industrial stages of the recycling sector, related to collection, separation and sale of waste and scrap. Labour intensity is higher than in KiCA, though still far below the rest of the CA, and in a similar level to the average of the economy. This group presents the largest average size firms in terms of number of employees, though displaying lower labour productivity and average remuneration than those of the KiCA. Therefore, it has been designated as low-wage capital-intensive circular activities (Lw-KiCA).

Group B1 includes repair activities of medium-high technological level products, such as the metal mechanic and electronic sectors and the repair of computers. The firms in these sectors are significantly smaller and have the highest levels of labour intensity, while unpaid employment has a relatively high share. Both wages and productivity are around the average of the economy and higher than in Lw-KiCA. This set of activities will be referred to as labour-intensive circular activities (LiCA).

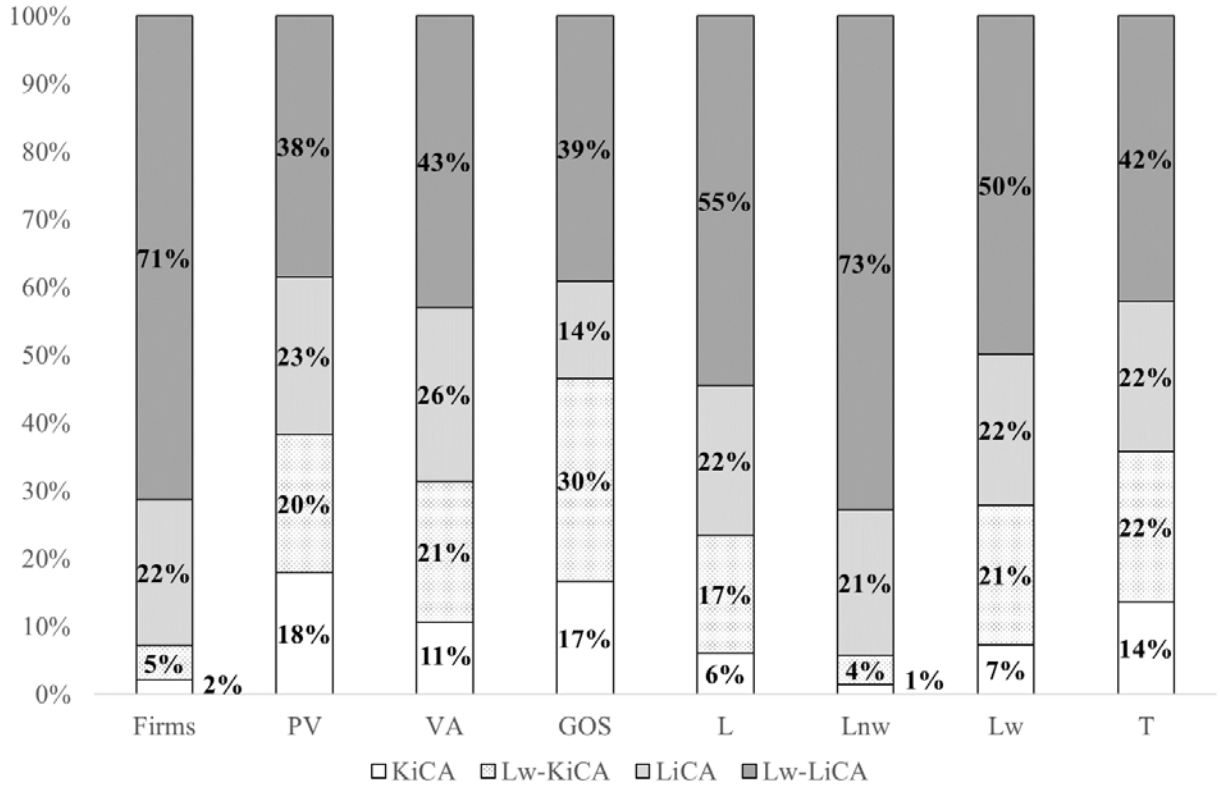
Finally, group B2 is made up of retail sale of used goods and medium and low productivity repair sectors, among which the repair and maintenance of motor vehicles stands out for its high

share in employment, production, VA and turnover. These activities combine, on average, similar labour intensity levels than those observed in the LiCA, though with wages 25% below the economy's average and a share of unpaid employment that reaches almost 30%. Therefore, this group will be labelled as low-wage labour-intensive circular activities (Lw-LiCA).

Data show that half of the people employed and almost 3 out of 4 firms and unpaid workers in circular activities belong to Lw-LiCA. This is due to a high extent to the sector of maintenance and repair of motor vehicles, which itself accounts for the 37% of remunerated workers, 47% of the firms and 48% of non-paid workers in all the CA.

Lw-LiCA account for about 38% of the total value of production and 43% of VA in the "circular" sectors. The second group in relevance is LiCA, which includes more than a fifth of the firms and paid workers and a quarter of the total value added. The share of Lw-KiCA is similar, although the proportion of firms is significantly lower in this group. Finally, KiCA have a relatively high share in total output (18%) considering that they involve only 2% of the firms and 7% of the paid workers (Figure 5).

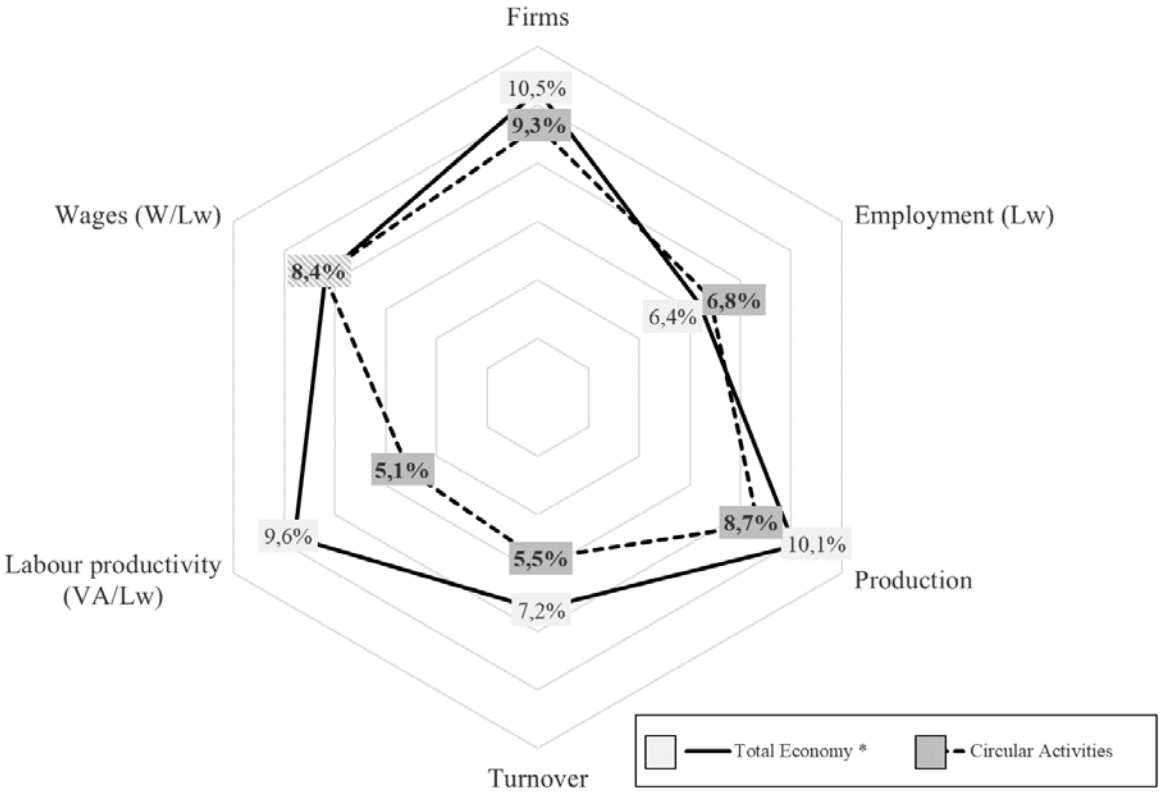
Figure 5: Share of each group of circular activities (CA) according to average labour productivity and capital/labour intensity. Main economic indicators*. 2016. EU-28.



* Firms, production (PV), value added (VA), gross operating surplus (GOS), employment (total, unpaid and paid - L, Lnw, Lw) and turnover (T)
SOURCE: Own elaboration on the basis of Eurostat.

As for the recent evolution of all the CA, between 2011 and 2016 the number of firms and paid employees, together with the average remuneration, grew in line with those on rest of the economy. During the same period, both production and turnover increased slightly less, while labour productivity only rose by half compared to the rest of the economic sectors (Figure 6).

Figure 6: Recent evolution of the circular activities (CA). Main economic indicators. 2011-2016. EU-28.



** Sectors included in Sections B to N plus Division 95 of Section S, NACE Rev. 2*
SOURCE: Own elaboration on the basis of Eurostat.

Increases in production and labour productivity concentrated mainly on LiCA and Lw-LiCA, whereas KiCA showed a decrease in both variables during the period (Table 1). Remunerated employment was more dynamic in Lw-KiCA and labour intensity increased remarkably in these sectors. Unpaid labour showed a significant expansion in LiCA (Table 2).

Table 1: Share of each group of circular activities (CA) according to labour intensity and average labour productivity. 2011-2016. EU-28.

CA Group	Firms		Employment		Production		Turnover	
	2011	2016	2011	2016	2011	2016	2011	2016
KiCA	1.9%	2.1%	7.9%	7.3%	20.7%	17.9%	15.6%	13.6%
Lw-KiCA	5.1%	5.0%	19.9%	20.6%	21.8%	20.4%	27.5%	22.1%
LiCA	16.8%	17.8%	20.0%	20.1%	19.6%	21.2%	15.6%	17.2%
Lw-LiCA	76.1%	75.1%	52.3%	52.0%	37.9%	40.5%	41.3%	47.1%

SOURCE: Own elaboration on the basis of Eurostat.

Table 2: Recent evolution of each group of circular activities (CA) according to labour intensity and average labour productivity. Main economic indicators. 2011-2016. EU-28. 2011 = 100.

Group	Labour productivity (VA/Lw)		Wages (W/Lw)		Labour intensity (Lw/GItg)		Unpaid labour (Lnw)	
	2011	2016	2011	2016	2011	2016	2011	2016
Total Economy *	100	109.6	100	108.4	100	94.4	100	101.7
Circular Activities	100	105.0	100	108.4	100	103.5	100	103.3
KiCA	100	95.0	100	111.2	100	87.1	100	106.8
Lw-KiCA	100	100.3	100	110.2	100	122.4	100	96.8
LiCA	100	109.5	100	105.6	100	98.0	100	115.6
Lw-LiCA	100	106.4	100	108.9	100	99.0	100	101.1

** Sectors included in Sections B to N plus Division 95 of Section S, NACE Rev. 2*

SOURCE: Own elaboration on the basis of Eurostat.

5. Conclusions and final remarks

The CE is made up of various and diverse activities that involve preserving the value of resources in cycles that range from the shortest (reduction, reuse, repair, refurbishment and remanufacturing) to the longest loops (recycling, recovery) (Reike et al., 2018). Each of these strategies correspond in turn to the different states of resources from the point of view of material entropy, ranging from the highest levels of order (products) to the lowest (particles), going also through the intermediate levels of disorder or diffusion (parts) (Blomsma and Tennant, 2020)

While a number of these CE-related tasks can be performed by a wide range of economic activities (e.g. eco-design, waste reuse, emission reduction, increased resource efficiency, etc), others are more directly identified to certain sectors, such as the case of recycling, repair and reuse. In a context of promotion of the CE at the European level, it is expected that the participation of these sectors will increase in the coming years. Whereas it is generally assumed that the environmental impacts of this change will be positive, less has been said about its socio-economic conditions and implications.This paper analysed the main economic features and recent evolution of the sub-sectors that compose the repair, reuse and recycling activities in the EU, considered together as “related to CE” (European Commission, 2018b) or circular activities (CA). It aimed to validate the hypothesis regarding their expected positive contribution to general employment due to their higher labour intensity, and to explore the specific economic

structural characteristics of the different sub-groups of activities that it comprises, in order to contribute to the formulation of more targeted and effective promotion policies.. To this end, a clustering of these sub-sectors was applied according to their average labour productivity and capital/labour intensity. The impact of each group on paid and unpaid employment, total firms, value added, turnover and the level of remuneration and gross operating surplus for each group was analysed.

The results confirmed that CA are currently relevant within the European economies, yet their weight is still modest considering the critical role they must play in the transition to a CE. Besides, it was possible to identify two major groups according to the level of capital/labour intensity of the sectors that compose them. The first one, characterised by higher levels of gross investment in tangible goods per worker, is formed by capital-intensive CA (KiCA) -mainly recycling (recovery of sorted materials)- and their auxiliary low-wage capital-intensive CA (Lw-KiCA) -waste collection, dismantling and trade-. The second group is comprised of labour-intensive CA (LiCA) -repairing and reuse- with different levels of complexity, productivity and wages.

More than half of the employment and firms are concentrated in low-wage labour-intensive CA (Lw-LiCA), with remuneration, productivity and investment levels per worker that are significantly below the European average. These are mostly micro and small establishments with high presence of unpaid work. On the other hand, there is a lower incidence of LiCA with wage levels equal to or higher than the average of the rest of the economic sectors, such as the repair of machinery and metal products. Unpaid employment has experienced a remarkable expansion in these activities in the recent years, while wages increased below the average.

Lw-KiCA also resent a relevant share in the total employment of the CA, and have been the most dynamic group in terms of remunerated employment in recent years. Unlike repair activities, these tasks are carried out by larger firms, although remuneration, productivity and investment levels remain below those of the rest of the economy. This is a sector that in essence does not imply a major break with the logic of the linear economy, which would actually depend on the subsequent treatment given to the waste. In contrast, KiCA involve only 7% of the workforce of all CA.

Disregarding the main limitation of the analysis, namely that it does not consider the impacts of CE outside the recycling, reuse and repair sectors, the results show the need for active intervention if such value preservation activities are intended to play a socially inclusive role in the transition towards CE. While the studied evidence confirms that CA are in general labour-intensive, there are significant differences between the various sectors involved.

On the one hand, reuse and repair activities in the EU were indeed found to be more labour-intensive than the average, whilst waste collection and recycling are comparatively capital-intensive. This raises a first question as to the extent of the impacts in terms of social inclusion of the current European CE strategy, which is mainly based on waste and recycling rather than on reuse and repair. Reuse and repair activities not only imply a stronger commitment to CE, since they directly contribute to the conservation of the value of products and the order of materials at their highest level for as long as possible, minimizing both waste and resource and energy consumption (Blomsma and Tennant, 2020; Reike et al., 2018; Stahel, 2019), but could also be the focus of a more cost-effective public policy strategy, as they could offer a greater job creation potential with less resource consumption due to their lower capital investment requirements. As emphasized by Stahel, waste collection or recycling are embedded in the current linear model to such an extent that, even though being circular activities, they become more important the more an economy develops following the linear paradigm (Stahel, 1997, 2019). This is due to the fact that they are an end-of-pipe solution to the still increasing amounts of resource consumption, related to the longest cycles of recovery of atoms and molecules, and usually energy-intensive activities. By contrast, reusing and repairing are more genuinely circular because they represent a closer loop that preserves value by enabling the extension of products life, minimizing both waste and resource and energy consumption. These activities, which are usually considered to be marginal, become key elements within a CE framework focused on the conservation of the value of products and materials at their highest level for as long as possibleIn the second place, the results highlight the marginal role reserved in the linear economy for value preservation activities that are key for the transition towards a CE, such as repair and reuse. This can be seen, for example, in the lower salaries and higher rates of unpaid work present among these labour-intensive CA. In this sense, a social revalorization of these activities leading to an improvement in working conditions is a necessary condition for the CE to deliver a genuine improvement from a socio-economic perspective.

Addressing this situation would require active intervention based on targeted public policies (Kirchherr et al., 2018; Milios, 2018; Stahel, 2013). Possible options to move in this direction could include promoting investment in infrastructure and installed capacity (Jackson, 2011), Technology innovation, research and development in SMEs, etc (Balke et al., 2017).. It should also be noted that some of the current industrial and fiscal policies may be appropriate for the KiCA sectors (large investments, R&D, public-private partnership, public procurement, regulations and standards, etc)but hardly suitable for most LiCA sectors, considering their particular economic features. Thus, new sectoral policies tailored to the repair and reuse activities should be developed, such asspecific fiscal and industrial policy measures to foster networks and make these sectors more competitive and innovative. An example would be the application of tax exemptions or reductions to such labour-intensive activities, so that they can improve their relative costs and their competitiveness vis-à-vis traditional sectors (ADEME et al., 2018a; Stahel, 2013). A similar effect may be achieved by reducing regressive taxes with a high burden on workers, such as value added tax or the lower categories of labour income tax (Groothuis, 2016; Stahel, 2019). This should go hand in hand with the promotion of eco-design, which is essential to ensure that products have a longer life and are more easily repaired (Dalhammar and Milios, 2016; Milios, 2018; Stahel, 2019; Vence and Pereira, 2019). (ADEME et al., 2018a; Stahel, 2013)(Groothuis, 2016; Stahel, 2019)Also, the public sector could assume directly these value-preservation tasks, or encourage the creation and development of associations and/or cooperatives for this purpose (Coraggio and Arancibia, 2014; Martínez Alier and Roca Jusmet, 2013).

A third issue that arises from the analysis concerns the participation of the sector of repair and maintenance of motor vehicles, which involves nearly 40% of all the paid and unpaid employment of the activities related to CE. Although this sector comprises very diverse type of establishments, from large brand agents and fast car-repair centres, to small independent repairers and specialists in windscreens or tyres (ADEME et al., 2018b), the data suggest the prevalence of firms with few or no employees. Some reports point out the relevance of European regulations to promote competition in the vehicle repair sector (European Commission, 2010, 2002; European Parliament and Council of the European Union, 2007) in determining the current configuration of the activity (ADEME et al., 2018b; European Commission, 2016). These legislation, which aims at ensuring that all actors have access to technical information and to the

original spare parts needed for automotive repair, has resulted in an increase in the relative share of independent repairers and self-employment, at the expense of the so-called 'manufacturer channel', consisting of brand agents and auto dealerships (ADEME et al., 2018b). However, the asymmetry in market power between the few large original equipment manufacturers and the multiple small independent operators, entails high costs of access to technical information for the latter, forcing their inclusion in franchise networks of the major brands (European Commission, 2016). As a result, it follows that many of the independent repairers are, in practice, outsourced employees of the original manufacturers, which implies a covert precarious labour relationship (Organization, 2014). In this respect, it may be of interest to encourage the structuring of repairers into independent professional bodies in order to strengthen their position in relation to manufacturers and distributors (ADEME et al., 2018b).

Finally, some questions emerge regarding the selection of indicators to monitor progress in socio-economic terms derived from the transition towards CE. Is it enough to account for net job creation in CA? Shouldn’t other dimensions linked to social welfare also be incorporated into the analysis? Meeting the three objectives of sustainability (Purvis et al., 2019) implies that environmental improvements cannot come at the cost of a worsening in the distribution of income and life’s quality (Dauvergne and LeBaron, 2013). In this regard, it is essential to monitor other relevant variables related to working conditions, such as wages, length and intensity of the working day, type and duration of contracts, access to social security and union representation, equal treatment and opportunities, and learning and professional development prospects, among others (Eurofound and ILO, 2019).

With regard to the remaining challenges for future research, efforts should be made to improve the quality of data collected on sectoral economic and labour market characteristics at the level of individual EU Member States. This would allow for a more detailed study of the structural features of CA from a territorial perspective, in order to identify potential disparities in the distribution of the socio-economic effects of the circular economy within the European Union.

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7. Annex

Table 3: Sectoral structure and economic characterisation of the circular activities (CA). 2016. EU-28.

Sector	CA group	Total Employ-ment	Firm size	Labour productivity		Avg. Wage	Unpaid labour	Labour intensity		Surplus rate
		Lw (thou.)	L/ Firms	VA/Lw **	VA/L **	W/Lw **	Lnw/L	Lw/GItg **	L/GItg **	GOS/T
Total Economy *		123.489	6	100	100	100	13%	100	100	11%
Circular Activities		3.190	4	79	72	88	21%	177	194	10%
Repair of fabricated metal products, machinery and equipment (C331)										
Repair of fabricated metal products (C3311)	*Li*	*78*	*5*	*98*	*95*	*123*	*15%*	*323*	*332*	*11%*
Repair of machinery (C3312)	*Li*	*358*	*5*	*92*	*88*	*109*	*17%*	*246*	*259*	*12%*
Repair of electronic and optical equipment (C3313)	*Li*	*41*	*4*	*106*	*96*	*120*	*21%*	*282*	*311*	*13%*
Repair of electrical equipment (C3314)	*Li*	*61*	*5*	*89*	*85*	*102*	*17%*	*365*	*380*	*14%*
Repair and maintenance of ships and boats (C3315)	*Lw-Li*	*90*	*6*	*71*	*73*	*87*	*11%*	*284*	*279*	*10%*
Repair and maintenance of aircraft and spacecraft (C3316)	*Ki*	*74*	*19*	*124*	*141*	*158*	*1%*	*100*	*88*	*8%*
Repair and maintenance of other transport equipment (C3317)	*Lw-Li*	*72*	*19*	*69*	*77*	*106*	*4%*	*211*	*190*	*4%*
Repair of other equipment (C3319)	*Lw-Li*	*14*	*3*	*75*	*70*	*77*	*20%*	*227*	*246*	*17%*
Waste collection (E381)										
Collection of non-hazardous waste (E3811)	*Lw-Ki*	*511*	*26*	*78*	*88*	*91*	*2%*	*122*	*108*	*13%*
Collection of hazardous waste (E3812)	*Lw-Ki*	*18*	*10*	*93*	*104*	*91*	*5%*	*119*	*107*	*12%*
Materials recovery (E383)										
Dismantling of wrecks (E3831)	*Lw-Ki*	*14*	*6*	*70*	*60*	*75*	*10%*	*122*	*144*	*9%*
Recovery of sorted materials (E3832)	*Ki*	*160*	*10*	*110*	*119*	*101*	*6%*	*71*	*66*	*9%*
Maintenance and repair of motor vehicles (G452)										
Maintenance and repair of motor vehicles (G4520)	*Lw-Li*	*1,168*	*3*	*69*	*59*	*75*	*26%*	*212*	*247*	*11%*
Sale, maintenance and repair of motorcycles and related parts and accessories (G454)										
Sale, maintenance and repair of motorcycles and related parts and accessories (G4540)	*Li*	*68 ****	*3*	*91*	*72*	*89*	*32%*	*206*	*263*	*6%*
Wholesale of waste and scrap (G4677)										
Wholesale of waste and scrap (G4677)	*Lw-Ki*	*112*	*5*	*86*	*83*	*82*	*16%*	*123*	*127*	*5%*

Retail sale of second-hand goods in stores (G4779)										
Retail sale of second-hand goods in stores (G4779)	*Lw-Li*	*90 *****	*2*	*47 *****	*38****	*58 *****	*35%*	*292*	*360*	*9%*
Repair of computers and communication equipment (S951)										
Repair of computers and peripheral equipment (S9511)	*Li*	*104*	*3*	*80*	*70*	*93*	*24%*	*416*	*479*	*12%*
Repair of communication equipment (S9512)	*Lw-Li*	*29*	*4*	*65*	*61*	*87*	*19%*	*424*	*452*	*5%*
Repair of personal and household goods (S952)										
Repair of consumer electronics (S9521)	*Lw-Li*	*22*	*2*	*64*	*44*	*64*	*41%*	*372*	*547*	*16%*
Repair of household appliances and home and garden equipment (S9522)	*Lw-Li*	*34*	*2*	*66*	*45*	*66*	*41%*	*407*	*598*	*17%*
Repair of footwear and leather goods (S9523)	*Lw-Li*	*12*	*2*	*67*	*31*	*56*	*59%*	*368*	*789*	*25%*
Repair of furniture and home furnishings (S9524)	*Lw-Li*	*14*	*2*	*76*	*43*	*67*	*51%*	*291*	*518*	*22%*
Repair of watches, clocks and jewellery (S9525)	*Lw-Li*	*6*	*2*	*59*	*32*	*61*	*54%*	*391*	*735*	*17%*
Repair of other personal and household goods (S9529)	*Lw-Li*	*40*	*2*	*66*	*32*	*59*	*58%*	*220*	*454*	*19%*

** Sectors included in Sections B to N plus Division 95 of Section S, NACE Rev. 2 ** Total Economy = 100 *** Data for 2015*

SOURCE: Own elaboration on the basis of Eurostat.