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The geography of circular economy: job creation, territorial embeddedness and local public policies

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Summary

To date, few studies have analysed the geography of the circular economy, especially its contribution to economic activity on a sub-regional scale. In this context, our paper aims to analyse the evolution of employment and activities in the circular economy at the local level in France. For this purpose, we use a database on job creation and companies in the circular economy between 2008 and 2015 and we propose for the first time a study measuring the creation of jobs and companies in the CE. We show that the growth of employment in the circular economy is higher than the growth of total employment. Moreover, we highlight that the number of companies in the circular economy is mainly concentrated in metropolitan areas. We also point out the regional effect of the growth of the circular economy, indicating the territorial embeddedness of this type of activity. Based on this observation, we assume that regional public policies play a significant role in the deployment of a circular economy.

Keywords: Circular economy, local public policies, employment growth, territorial embeddedness, spatial concentration.

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INTRODUCTION

The circular economy (CE) has gained interest in recent years among the general public, companies and local authorities (Urbinati et al., 2017), which consider it a key strategic imperative for the operational implementation of sustainable development (Kirchherr et al., 2017) or a way to locally anchor economic activities and implement new commercial strategies and responsible consumption behaviours (Bourdin et al., 2022). At the European level, CE is seen as a means to reindustrialise the continent (Bourdin and Torre, 2020). For the European Union (EU), this is a strategic objective for ecological and energy transition and is considered essential to ensuring the sustainable development of regions and cities (European Commission, 2015 and 2020). To curb the use and waste of resources and tackle pollution, CE should enable sustainable economic growth by creating more wealth with either the same amount of material or less material (Stahel, 2013, 2016; Haas et al., 2015; Gregson et al., 2015; Millar et al., 2019).

At the local level, CE is increasingly supported by public funding (da Silva, 2018; Kębłowski et al., 2020) and mobilises numerous stakeholders in territorial development (Bourdin and Nadou, 2021; Jambou et al., 2021). For local authorities, it is increasingly being regarded as a strategic objective because it allows for (i) improving productivity and resource efficiency, (ii) enhancing local growth potential, (iii) implementing all types of innovations and (iv) creating new activities that provide jobs and wealth (Stahel, 2016; Repp et al., 2020; Bourdin and Torre, 2020). In fact, in France, as in more and more countries, it is developing at a rapid pace, as shown by the interest in activities such as collaborative consumption solutions (carpooling, etc.), eco-designed production, repair, second-hand sales, recycling and waste recovery. These new circular activities represent important growth-enhancing business models for productive actors (Preston, 2012; Urbinati et al., 2017). They increase the resilience of firms in the face of volatile commodity prices and create value and wealth while preserving the environment as much as possible (Lieder and Rashid, 2016; Garces-Ayerbe et al., 2019). Therefore, the commitment to circularity reflects the desire of public and private actors to ensure economic growth that has less impact on the environment and preserves the social well-being of populations. From this point of view, Geissdoerfer et al. (2017) explain that CE can be seen as a new paradigm responding to sustainable development objectives. In this context, local territories appear to be an appropriate level of intervention and implementation of circular initiatives. Regions and cities should play a decisive role in developing the EC's economic, social and environmental potential (Bourdin et al., 2022).

Various studies have recently focused on the economic evaluation of the impact of CEs in terms of cost reduction. However, given the various definitions and measurement difficulties (Korhonen et al., 2018), measuring CEs is still complex (Rizos et al., 2017). This may explain why there is a lack of academic work explicitly measuring direct job creation and activities in the CE, neither at the country level nor at the sub-regional level (Sulich and Sołoducho-Pelc, 2022). Given the difficulties in obtaining data on job creation in the CE, researchers propose estimating job creation in the green economy as a proxy (Horbach et al., 2017), but Van Oort et al. (2018) explain that these approaches probably underestimate the reality of CE. Today, only a few studies extrapolate job creation in CEs (Bastein et al., 2013; Cambridge Econometrics and Bio Intelligence Services, 2014; Wijkman and Skanberg, 2015). With the exception of a few applied studies, such as those by CIRCTER[1] (CIRCTER, 2019) or the WRAP and Green Alliance groups[2] (Morgan and Mitchell, 2015), which offer some regional analyses, there is no work attempting to analyse the geography of the CE and its evolution at a sub-regional scale, even though CE experiments are often implemented locally or regionally.

In this context, we answer the question of how circular economy activities are growing and the extent to which they are being deployed on a local scale. The contribution of our article is twofold. First, based on unreleased data, we propose a study measuring the creation of jobs and companies in the CE. Second, we explore how this deployment of CE takes place at the local level. To do so, we conduct a spatial analysis of the evolution of the CE between 2008 and 2015. For this investigation, we focus on France as a case study, for which we have collected data from the National Secure Data Access Centre. The statistical grid used is the employment zone (EZ)[3], which allows us to carry out an analysis at the infra-regional scale, which is unprecedented in the literature. By studying the spatial concentration of jobs and companies in the CE and their evolution, we can investigate the extent to which public policies may play a role in the deployment of such activities.

[1] Circular Economy and Territorial Consequences (CIRCTER) is a European applied research project co-funded by the European Regional Development Fund, the EU Member States and the partner states Iceland, Liechtenstein, Norway and Switzerland. It was implemented by a network of teams from four EU countries, which analysed the territorial determinants of circular economy growth.

[2] Morgan and Mitchell (2015) conducted a study for the WRAP and Green Alliance groups, analysing the potential for labour market job creation in Britain through improved resource efficiency through circular economy activities. In part, this work adopts a spatialized regional approach to jobs generated by circularity practices.

[3] The National Institute of Statistics and Economic Studies (INSEE) defines the EZ as "a geographical area within which most of the active population resides and works, and in which establishments can find most of the labour required to fill the jobs on offer".

In the remainder of this article, we first present our framework of analysis, which defines the circular economy and how it can generate job creation, before detailing the research methodology in the second section. The results are presented in the third section. The last part of our paper is dedicated to the conclusion, discussion and recommendations.

1. LITERATURE REVIEW

1.1. Defining circular economy

Population growth, increasing economic activity and rapid urbanisation are driving changes in consumption and production patterns around the world, resulting in increasing resource exploitation and exponential waste generation (Schroeder et al., 2019). In this context, the authors explain that the implementation of a circular economy can be a way to address these challenges.

The concept of a circular economy was first introduced by two British environmental economists, Pearce et al. (1990). The authors develop the idea that it is necessary to consider the Earth as a closed economic system. They take up the idea developed by Boulding (1966) that the interrelations between the economy and the environment are not linear but circular. Geissdoerfer et al. (2017) go even further and explain that circular economy can be considered a new paradigm around sustainability issues, and that it is based on the idea of a regenerative system.

Several authors point out the lack of consensus on the definition of circular economy (Kirchherr et al., 2017; Blomsma and Brennan, 2017; Korhonen et al., 2018). However, most researchers agree that the implementation of a circular economy should meet three main 3R principles (Reduce, Reuse and Recycle). Reduction refers to the need to minimise the input of primary energy and raw materials by improving production efficiency. Reuse refers both to the use of a company's by-products and waste as a resource for other companies or industries and to the use of products to their fullest capacity, through frequent maintenance and recovery to extend their life. Recycling encourages the transformation of recyclable materials into new products to reduce the consumption of virgin materials. Geissdoerfer et al. (2017) explain that these different principles have a hierarchical importance: the reduction of resource use being the guiding principle in a circular economy system, then the reusing and finally the recycling.

In 2013, the foundation Ellen MacArthur proposed a definition of circular economy, which is often taken up and discussed in the literature (Suárez-Eiroa et al., 2019), integrating the three

main 3R principles that it promotes to productive actors. For our paper, we prefer the definition of circular economy by Kirchherr et al. (2017), which is commonly accepted: "A circular economy describes an economic system that is based on business models which replace the 'end-of-life' concept with reducing, alternatively reusing, recycling and recovering materials in production/distribution and consumption processes, thus operating at the micro level (products, companies, consumers), meso level (eco-industrial parks) and macro level (city, region, nation and beyond), with the aim to accomplish sustainable development, which implies creating environmental quality, economic prosperity and social equity, to the benefit of current and future generations.". This definition thus has the advantage of integrating, alongside the environmental benefits, the potential positive effects of circular economy practices, particularly in terms of job creation, increased well-being of populations, and resilience of actors at different scales of implementation.

However, according to Saavedra et al. (2018), circular economy is not limited to these three principles. They also identify the economy of functionality (Bocken et al., 2014; Meier et al., 2010; Nyvall et al., 2022) eco-design (which consists of integrating the end of life of the product, environmental protection and the limited use of resources from the design of the product or service) as well as industrial and territorial ecology (which consists of saving or improving the productivity of resources by sharing/pooling them with companies and organisations in a given territory). These approaches, while promoting cooperation between producers, service providers and consumers, also encourage the application of the 3Rs principle through the reuse, repair and reuse of products, reduction of resource and energy consumption, and recycling and recovery of waste.

1.2. Circular economy, job creation and the role of public policies

Given the potential for job creation in the CE and the impact on economic growth (European Commission, 2015), public authorities are increasingly taking up this issue. This is all the more true as CE constitutes opportunities for territorial development (Bourdin et al., 2022). It also allows for the territorialisation of economic activities (Cerceau et al., 2018), notably via the implementation of policies favouring the development of industrial and territorial ecology (Bourdin and Torre, 2020). Furthermore, Murray et al. (2017) explain that a circular economy promotes more sustainable business models. Given the diversity of ways of doing CE (see Section 1.1.), this new economic model represents new technological, socio-economic and

environmental opportunities. Consequently, public authorities have multiple ways of seizing to deploy CE (Bourdin et al., 2022).

The starting point for the implementation of CE by public authorities began in 1996 in Germany with the enactment of the "Closed Substance Cycle and Waste Management Act". Following Germany's lead, other developed countries followed suit in operationalising CE. The European Commission also proposed its own action plan in 2015, fixing targets for landfill, reuse and recycling. More generally, Dagilienė et al. (2021) point out that great efforts have been made by local governments to promote waste sorting and reuse or repair. This raises the question of the effects of these public policies on job and companies' creation. Kębłowski et al. (2020) explain that many cities are in the process of proposing agendas for deploying CE to achieve the 2030 Sustainable Development Goals. Cerceau et al. (2018) and Jambou et al. (2021) point out that an increasing number of local authorities are deploying industrial and territorial ecology approaches to foster the implementation of CE at the local level.

To date, there is no scientific work assessing job creation. The EU's Circular Economy Action Plan (European Commission, 2015) estimates the potential for net job creation to be in the order of 700,000 compared to the baseline scenario by 2030. Given the lack of academic work directly measuring job creation in the circular economy, Horbach et al. (2017) propose measuring its effects by looking at job creation in the green economy. They start from the definition of green jobs according to UNEP (2008) and explain that it is reasonable to consider that job creation in the circular economy can be linked to job creation in the green economy: "jobs that contribute to protecting ecosystems and biodiversity; reducing consumption of energy, materials and water through high efficiency strategies; decarbonising the economy and minimising or completely avoiding the production of all forms of waste and pollution". Moreno-Mondéjar et al. (2021) and Sulich and Sołoducho-Pelc (2022) start from the same observation and also consider this premise in their study. Van Oort et al. (2018), for their part, explain that by focusing only on green jobs, gross job creation in CE is underestimated. Nevertheless, if we look at the work that has assessed job creation in the green economy, studies show that the green economy is job-creating (Stanef-Puică et al., 2022).

2. DATA AND METHODOLOGY

Our study aimed to measure the growth of circular employment and assess possible trends in terms of spatial concentration. This measurement was based on the use of a series of indicators, mobilising data from companies involved in the circular economy. The cartographic

analysis of some of the indicators at the sub-regional scale (*employment areas*) allowed us to observe the geography of the deployment of the circular economy.

2.1. Data and definition of the scope of the circular economy sphere

To focus on the study of the evolution of circular activities at the level of establishments and companies, we used data on the number of establishments and salaried employment according to the place of work between 2008 and 2015. They were extracted from the INSEE's statistical source of the local productive apparatus. We chose this period because it is from 2008 onwards that we observe a 'take-off' of the circular economy in France (ADEME[4], 2014), while 2015 corresponds to the promulgation of the law on the energy transition for green growth (18 August 2015), which recognises the transition to CE as a national objective for achieving the 2030 Sustainable Development Goals.

We then identified, in the French nomenclature of activities (NAF), those that could fall within the scope of the CE. The list of activities is not exhaustive, particularly for the industrial and territorial ecology or the economy of functionality (except for rental activities), which are not referenced as such by the NAF. This is a limitation of our study, which cannot be filled by the available data.

Table 1: Identification of activities in the circular economy

Circular economy sphere	References	Number of circular activities	Selected circular activities
Economy of functionality	Meier et al., 2010; Bocken et al., 2014; Nyvall et al., 2022	15	Rental
Extension of the duration of use	Kirchherr et al., 2017; Blomsma and Brennan, 2017; Geissdoerfer et al. 2017	21	Maintenance and repair Repair and maintenance Trade and repair Trade in second-hand goods Business-to-business trade in waste and scrap
Recycling and waste recovery	Blomsma and Brennan, 2017; Korhonen et al., 2018	11	Dismantling of wrecks Demolition work Wastewater collection and treatment Waste collection Treatment and disposal of waste Recovery of sorted waste Remediation and other waste management services Production of gaseous fuels Steam and air-conditioning production and distribution

[4] The French National Agency for Ecological Transition

In total, 47 circular activities were identified with the NAF codes for the main activities of the companies. The data were extracted from the National Secure Data Access Centre, which provides information on salaried employment for each company in France. We aggregated this data at the level of EZs in France (n = 304 spatial units). We chose this spatial unit of analysis because the EZ is characterised by both a residential and an economic vocation (specificity of the local business fabric). It aims to take into account the local market through exchanges between companies and employees–consumers. Moreover, it constitutes an area where the density of inter-firm relations is important.

2.2 Statistical measures of local circular employment dynamics

The estimation of a series of statistical indicators allowed us to assess the temporal and spatial evolution dynamics of the development of CE in France. We used as indicators the employment growth rate, the location coefficient, the economic density (of companies and employment) and the *Moran I* statistic (see Annexe 6). These statistical measures are generally mobilised in empirical studies analysing issues of the location of economic activities to identify concentrations and characterise their geographical distribution (Combes et al., 2011).

We began by estimating the absolute growth rate of circular employment at the national level, obtained by the ratio of the change in the number of jobs between 2008 and 2015. This allows us to reflect on the growth of circular employment in the national economy and account for its weight. The mapping of the indicators provides an overview of the geography of the circular economy by identifying the geographical distribution of circular activities and their evolution. Then, we utilized the most widely used concentration indices (location coefficient and economic density) to measure the geographical distribution of activities (Combes et al., 2011). Finally, estimation of *Moran's I-statistic* makes it possible to test the existence of a spatial concentration (Anselin, 1996) of circular activities. More precisely, the objective here is to determine whether the growth of circular companies in an EZ tends to be similar to that observed in neighbouring EZs.

3. RESULTS

3.1. Higher growth in circular employment than in total employment

Around 2% of the jobs created in the French economy can be included in circular practices, which represents the equivalent of 576,000 people employed in this sector in 2015 (see Table 2). The activities of extension of the useful life of goods – which include activities of repair,

maintenance, reuse and re-utilization of goods – are the most important providers of circular jobs, with 243,167 employees (42% of the total), followed by the activities associated with recycling and waste recovery, which make up 30% of all circular jobs. These results are interesting as they confirm the idea of waste hierarchy in the circular economy, as indicated by Geissdoerfer et al. (2017). We find the order defined by these authors in our results: reuse/repair what you can and recycle what cannot be reused. This is rather encouraging, especially in a context where Morseletto (2020) explains that CE is too often reduced to the issue of recycling, when the priority should be to reduce or reuse/repair.

Table 2: Changes in circular jobs in metropolitan France between 2008 and 2015

Circular economy sphere	Number of jobs				Evolution	
	2008		2015			
	Workforce Employees	%	Workforce Employees	%	Absolute change	Growth rate
Whole economy	**26 337 759**	**100**	**26 730 677**	**100**	**392 918**	**1,49**
Circular economy	**558 986**	**2,12**	**575 864**	**2,15**	**16 878**	**3,02**
Economy of functionality	154 263	0,59	159 541	0,60	5 278	3,42
Extension of the duration of use	240 904	0,91	243 167	0,91	2 263	0,94
Recycling and waste recovery	163 819	0,62	173 156	0,65	9337	5,70

In terms of evolution, the 3% net growth of circular jobs between 2008 and 2015 was higher than the trend observed during this same period for total employment (1.49%). The increase is driven by a more or less strong dynamic of all circular activity sectors. However, activities related to the recycling and recovery of waste have the highest growth, at around 6%, compared to 1% of the additional jobs created for activities that extend the useful life of goods. This can be explained by the fact that many investments have been made by local authorities to develop more technologically efficient waste management plants (Bourdin et al., 2022). It can also be argued that more and more communication is being done with citizens to support waste-sorting initiatives (Dagilienė et al., 2021).

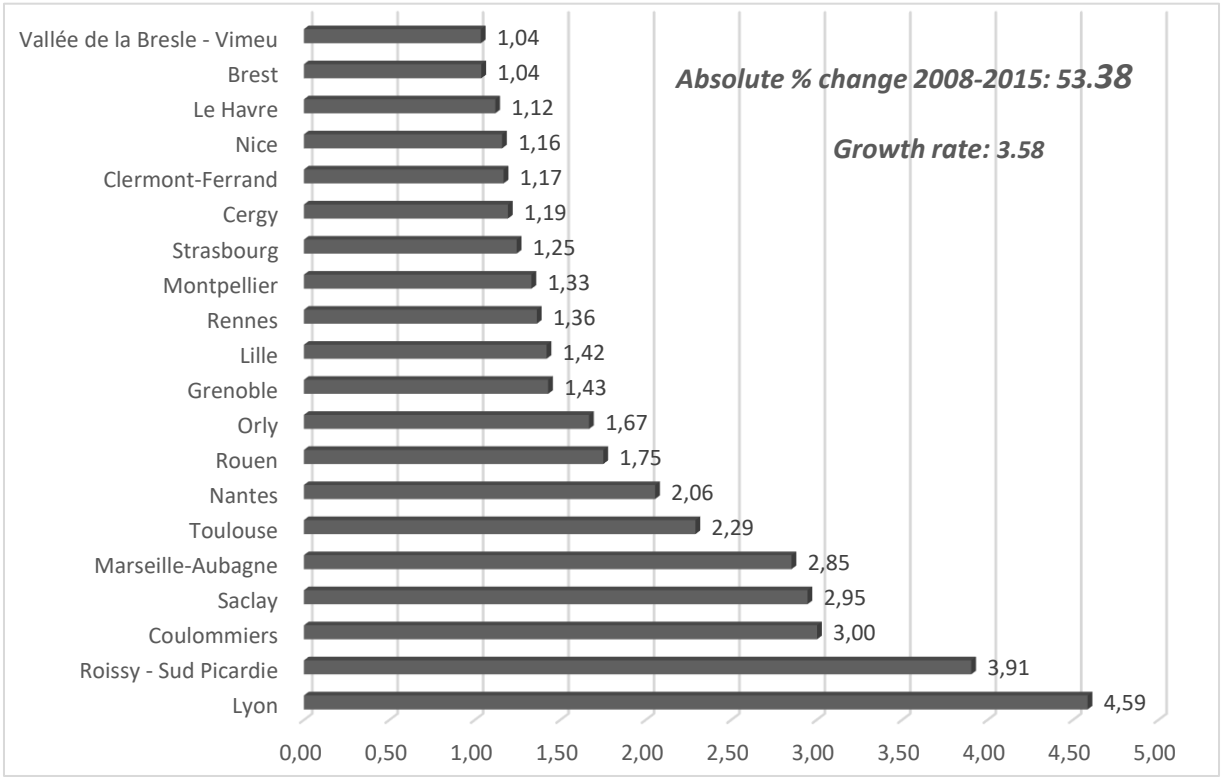
We can also notice that the CE sphere "extension of the duration of use" employed more people than the "recycling and waste" sphere at the end of the period (42% compared to 30% of total circular jobs in 2015). Furthermore, the functionality economy shows a growth rate of around 3.42%, which is slightly higher than the overall growth of circular activities, although it contributes less to job creation. This is confirmed by the CIRCTER report (2019), which stresses

the importance of agglomeration effects linked to the implementation of new service business models.

3.2. More metropolitan circular activities

Observation of the dynamics of the circular economy reveals that it is not evenly distributed across areas. Figure 1 represents the relative weight of the 20 EZs with the highest concentration of circular jobs in 2015 (excluding Paris and the EZs of Corsica). These 20 first EZs concentrate on 195,695 employees, or slightly more than a third (38.57%) of metropolitan employment[5]. These territories play by far the most important role in circular economic transformation, with a maximum of 23,271 employees located in Lyon (which concentrates 4.59% of total circular employment in France).

Figure 1: Relative weight of the 20 employment areas with the most circular jobs in metropolitan France (excluding Paris and Corsica)



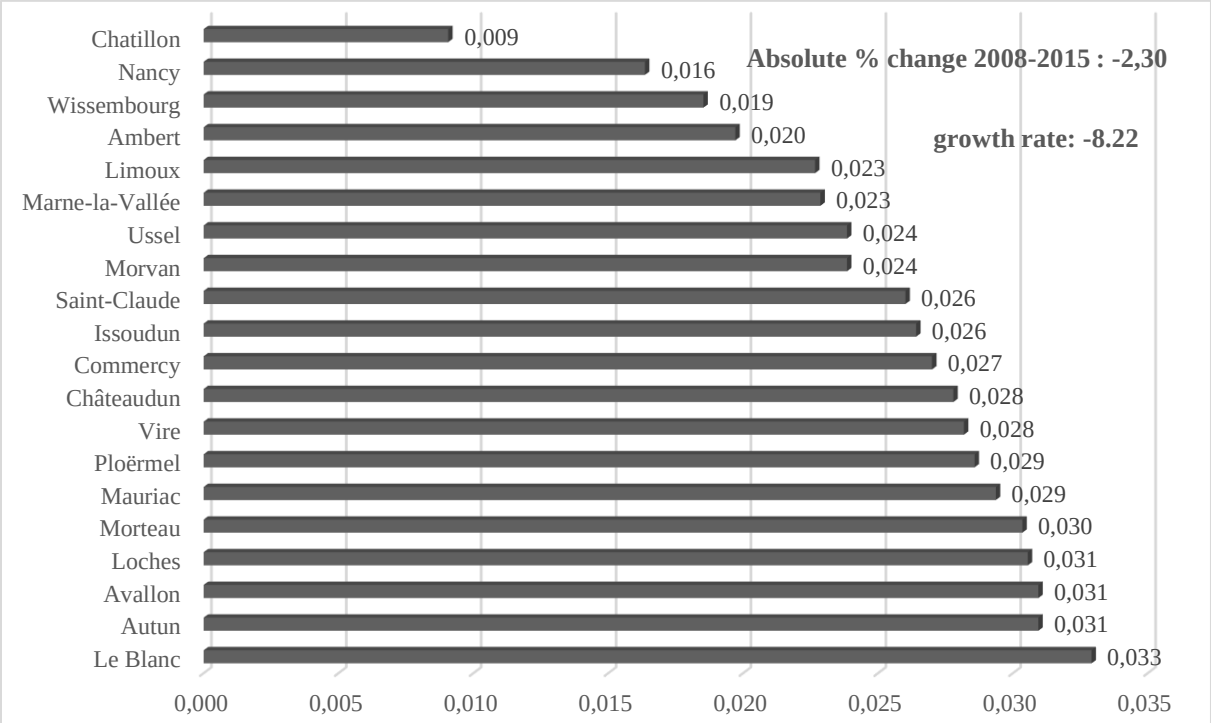
Between 2008 and 2015, the number of jobs located in these territories rose from 186,336 to 195,695, for an absolute variation of 9,359 jobs, which represents a relative weight of 53.38% of the total jobs created in France and a growth rate of 3.58%. An increase of around 15% can be observed in Roissy-Sud Picardie, which is under the shared influence of the Ile de France and

[5] See the results including Paris and Corsica in the annex.

Hauts-de-France regions. It is also worth noting that these areas, which concentrate most of the circular jobs, correspond to the most populated cities.

This logically raises the question of the place and role of more peripheral territories, particularly rural ones, in the dynamics of the circular transformation of the economy. Figure 2 deals with the relative weight of the 20 employment areas with the lowest concentration of circular employment in 2015. It clearly shows that these areas – whose circular activities are among the least important in metropolitan France – are mostly sparsely populated.

Figure 2: Relative weight of the 10 employment areas with the fewest circular jobs in metropolitan France (excluding Paris and Corsica)



Thus, the circular economy is comparatively less established in these low population density territories. The number of employees working in circular activities decreased over the study period by 8.22%, from 2,797 to 2,567 circular jobs in 2015, a relative weight of only 0.51%. This situation contrasts with the employment areas of the metropolises, which participate significantly in the development dynamics of the circular economy. This result can be linked to the fact that urban areas have made the circular economy a priority topic in their economic development policies (Kębłowski et al., 2020). Cerceau et al. (2018) show that the territorial embedding of resource management is particularly developed in metropolitan areas through the development of urban industrial symbiosis approaches.

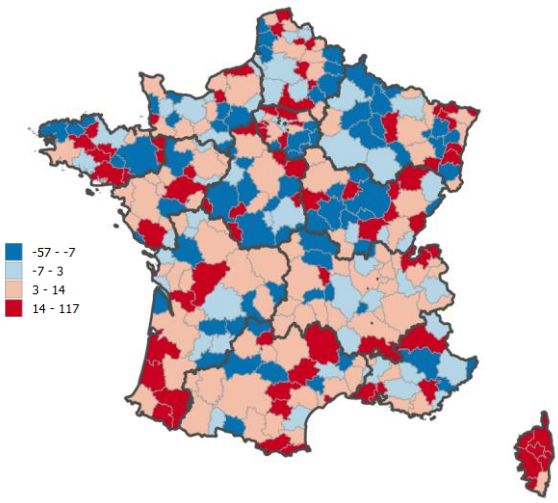
3.3. A strong regional effect of the spatial distribution of circular activities

Figure 3 shows the evolution of circular jobs and the locations of companies in the CE. We observe a dispersion of the progression of jobs throughout France, with a specific growth in the large cities.

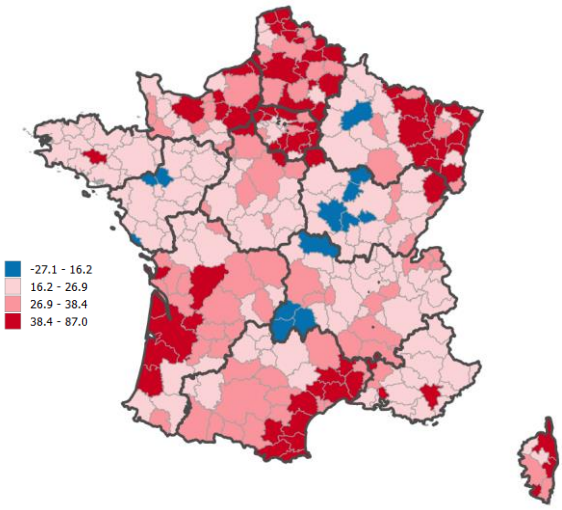
Regarding the creation of circular activities, we can observe that it seems to follow the logic of regional administrative divisions. The evolution of circular activities is particularly marked in certain regions (Hauts-de-France, Ile-de-France, Grand-Est, Occitanie and Nouvelle-Aquitaine). Bourdin and Torre (2021) explain that territorial reform in France has resulted in increased power for regional authorities. The latter has taken control of the economic development of the regions and the ecological transition. Consequently, some of them have been very active on EC issues, as it represents a means of territorialising industry and greening productive activities (Bourdin and Torre, 2021).

Figure 3: Changes in the number of circular jobs and circular establishments between 2008 and 2015

Growth rate of circular employment



Growth rate of circular establishments

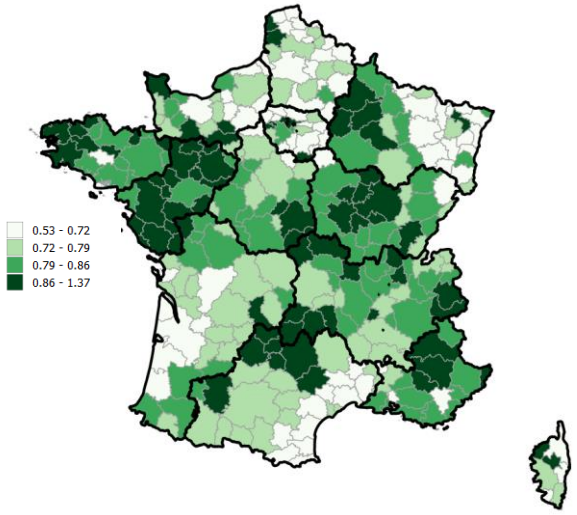


Consequently, it can be hypothesised that the spatial concentration effects that follow the contours of the regions highlight the incentive role of funding and public policies. Certain regional authorities have been specifically committed to the implementation of public policies favouring the deployment of CE. In particular, Hauts-de-France and Occitanie – which have both experienced notable growth in circular employment – have higher unemployment rates than other regions in France. The Hauts-de-France Region has been implementing regional policies to reorient its highly industrialised economic model since the early 2000s. The Ecological and

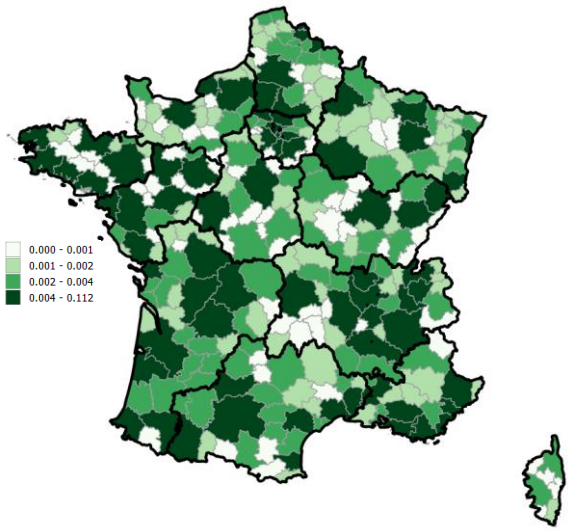
Social Transformation Plan and the Third Industrial Revolution projects (Rifkin, 2013) have fostered partnerships and local dynamics (Belarouci, 2022), thus contributing to the emergence of CE activities, particularly in territories in decline due to unemployment. Jobs related to waste collection, treatment and recycling activities are particularly important in certain employment areas of the region, such as Dunkirk, Flanders-Lys and Lens-Hénin (Vidalenc, 2019). For the Regional Council of Occitania we identify a political will in the regional planning documents[6] to make the CE a priority for economic development, with a particular focus on rural areas.

Figure 4: Location coefficient of circular companies in France between 2008 and 2015

Weight of EZs in the total number of circular companies in 2008 (%)



Weight of EZs in the total number of circular companies in 2015 (%)



It is also possible to observe the effects of local public policies towards CE in the maps in Figure 4. We calculated a location coefficient for each EZ in 2008 and in 2015, respectively. They clearly indicate that the territories that have experienced the most significant increase in circular activities (Figure 3 – growth rate of circular companies) were less developed in CE activities at the beginning of the period in 2008 (Figure 4). This observation highlights a sort of catching up of some territories, reinforcing the hypothesis of the positive effects of local public policies on the development of CE. Jambou et al. (2021) highlight how local public policies have enabled some companies to develop their circular activities, notably by promoting inter-firm cooperation. They underline that these local authorities are implementing industrial and

[6] https://www.laregion.fr/Environment-and-Landscapes

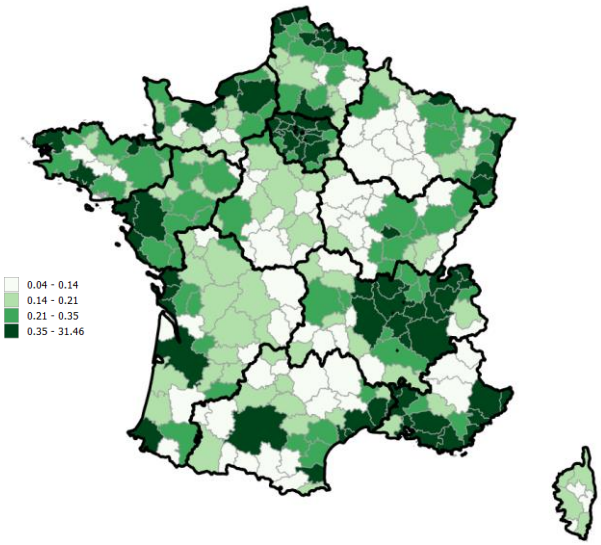
territorial ecology approaches, financed in part by the local level but also by the national level via the French Agency for Ecological Transition. Cerceau et al. (2018) pointed out that this type of industrial and territorial ecology approach allows for the local embeddedness of economic activities.

3.4. A vacuum diagonal of circular economy activities

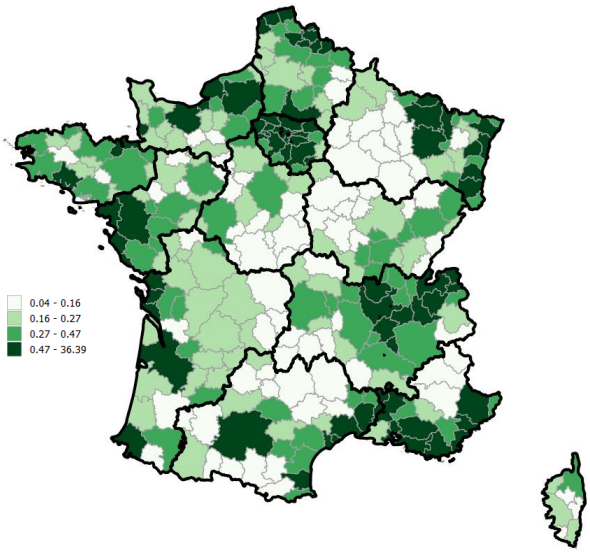
As we have seen, the geographical distribution of circular activities appears to be correlated with high-density EZs. The mapping of the density of companies (Figure 5) shows that the latter is particularly high in regional metropolises. Conversely, there is a clear pattern of low economic density of circular activities corresponding to the French "*diagonal of emptiness*"[7] and which is increasing. The EZs comprised in this "diagonal of emptiness" are known for their low economic attractiveness and are characterised by the existence of large agricultural areas.

Figure 5: Number of circular economy establishments per km² in 2008 and 2015

Number of circular establishments per km² in 2008



Number of circular establishments per km² in 2015



The Moran's I index measuring spatial autocorrelation makes it possible to highlight the geographical concentration of economic activities at the national level (Table 4). Taken as a

[7] This notion, which is often contested (Oliveau and Doignon, 2016), refers to a representation of territories that are less populated than the French average, forming a band that crosses the country from the North-East to the South-West.

whole, there is a significant spatial concentration in the location of circular economy activities in the metropolitan area.

Table 4: Moran's I index of establishment growth in the circular economy

Circular economy activities	Moran's I	p-value
Circular economy as a whole	**0,264**	**0,010**
Economy of functionality	0,227	0,010
Extension of the duration of use	0,191	0,010
Recycling and waste recovery	-0,095	0,350

However, not all sectors of the circular economy show the same level of spatial concentration, particularly in the case of waste recycling and recovery activities, which appear to be well-distributed over the national territory. This can be explained by the fact that each community of municipalities (or equivalent) has the capacity for waste treatment, which induces a rather spatial dispersion, and that this activity of waste treatment is also being developed in rural areas through the implementation of biogas activities (Niang et al., 2022a, b). On the other hand, there is a spatial concentration of the economy of functionality and extended-use initiatives, which tend to be located in urban and peri-urban areas (Kębłowski et al., 2020). It can be hypothesised that these activities are linked to the presence of higher social categories and higher levels of education in the most urbanised areas in which people adapt their ways of consuming according to the imperatives of the CE (Muranko et al., 2018).

CONCLUSION & IMPLICATIONS

Our study of the spatio-temporal dynamics of circularity activities aimed to analyse at a fine geographical scale the concentration of circular jobs and activities. Stanef-Puică et al. (2022) explained that there are no studies analysing actual job creation in CE, partly due to data availability. From this point of view, our article constitutes a significant contribution to the literature by proposing an analysis of job creation and the creation of companies in the CE and

its development at the local scale. We have shown that the circular economy has strong potential for job creation at the national level. However, by describing the spatial distribution of circular activities, we have highlighted that behind this overall growth, some territories seem to be taking the lead in applying the CE transformation. The trend towards a spatial concentration of CE, with a regional logic, also suggests a likely effect of regional public policies.

In a systemic and integrative vision of deployment strategies, the regional authority can thus be considered a level that drives the coordination of CE actions in territories (Bourdin et al., 2022) and strengthens mobilisation and cooperation between local actors (Bourdin and Nadou, 2020). Nevertheless, significant disparities can be seen at the level of sub-regional territories, suggesting significant idiosyncrasies at the local level. This is in line with the work of Lamine et al. (2018), who, based on an analysis of green ecosystems, highlighted the crucial role played by local public policies and institutions in the dynamics of the emergence of new green technologies. Our results also confirm the studies of Cerceau et al. (2018) and Bourdin et al. (2022) on the role of regional policies in fostering CE deployment.

Consequently, the regional authority should play a key role in supporting the implementation of the CE. For example, regional authorities could consider carrying out a systematic survey of the types and quantities of resources used and waste produced each year by the regional socio-economic system. It could also be useful to identify dynamic sectors that lend themselves well to the implementation of industrial and territorial ecology approaches. A study of EC business models among regional companies would make it possible to identify good practices that could serve as an example of deployment on a local scale. Finally, to encourage companies to engage in EC, it could be relevant to systematically integrate EC criteria into public procurement.

Given the systemic changes involved in the circular economy (Desing et al., 2020), local authorities need tools to monitor and track progress across a range of parameters. Indeed, our study can serve as a basis for developing a quantitative evaluation of local CE policies and strategies. The data could also enable the development of predictive models for local authorities to assess how the transition to a circular economy impacts the local labour market. Based on these predictions, it could be possible to implement more active place-based policies in terms of employment. From this point of view, the state could financially support cities that wish to develop CE and for which the potential for creating activities is high.

A current limitation of the study concerns the available databases. While we have been able to capture the sectors of activity related to recycling, re-use and re-purposing, it is not always easy

to identify the different forms of circular economy. This observation concerning the data should constitute a working basis for the data-producing organisations, so as to rethink – at least in part – the current classification of activities, which is still based on a linear economy and does not yet adequately reflect the bases of a circular economy. Moreover, our results suggest an effect of local public policies without testing them from an econometric point of view. Future research could therefore seek to analyse the extent to which public policies influence job creation, for example, by using counterfactual methods.

Our research is exploratory and proposes to open new fields of research on the implementation of CE strategies, as well as on the explanatory factors contributing to job creation at the local level. In future research, it would be interesting to identify the respective weights of each CE sector and to analyse the specific evolution of these activities. In the same vein, an index of CE jobs could be developed based on the hierarchy defined by Geissdoerfer et al. (2017) to analyse which territories are most engaged in CE. It would also be interesting to evaluate the growth in employment after 2015, the year in which the law on ecological transition and circular economy was implemented in France. Then, evaluating the extent to which the legislation has accelerated the growth (or not) of the CE on a local scale could be another avenue of research.

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APPENDIX 1: NAF codes (INSEE) for activities in the circular economy sphere

Circular economy sphere	NAF	Activities
Economy of functionality	4399E	Hire with operator of construction equipment
	4941C	Truck rental with driver
	7711A	Short-term rental of cars and light motor vehicles
	7711B	Long-term rental of cars and light motor vehicles
	7712Z	Truck rental and leasing
	7721Z	Rental and leasing of leisure and sporting goods
	7722Z	Rental of videocassettes and video discs
	7729Z	Rental and leasing of other personal and household goods
	7731Z	Rental and leasing of agricultural machinery and equipment
	7732Z	Rental and leasing of construction machinery and equipment
	7733Z	Rental and leasing of office machinery and computer equipment
	7734Z	Rental and leasing of water transport equipment
	7735Z	Rental and leasing of air transport equipment
	7739Z	Renting and leasing of other machinery, equipment and tangible goods n.e.c.
Extended life span • Reuse • Repair • Reuse	3311Z	Repair of metalwork
	3312Z	Repair of machinery and mechanical equipment
	3313Z	Repair of electronic and optical equipment
	3314Z	Repair of electrical equipment
	3315Z	Ship repair and maintenance
	3316Z	Repair and maintenance of aircraft and spacecraft
	3317Z	Repair and maintenance of other transport equipment
	3319Z	Repair of other equipment
	4520A	Maintenance and repair of light motor vehicles
	4520B	Maintenance and repair of other motor vehicles
	4540Z	Trade and repair of motorbikes
	4677Z	Wholesale (business to business) of waste and scrap
	4779Z	Retail sale of second-hand goods in shops
	9511Z	Repair of computers and peripheral equipment
	9512Z	Repair of communication equipment
	9521Z	Repair of consumer electronics

	9522Z	Repair of household appliances and home and garden equipment
	9523Z	Repair of footwear and leather goods
	9524Z	Repair of furniture and household equipment
	9525Z	Repair of watches and jewellery
	9529Z	Repair of other personal and household goods
Recycling and waste recovery	3521Z	Production of gaseous fuels (methanisation, gasification)
	3530Z	Steam and air conditioning production and distribution
	3700Z	Wastewater collection and treatment
	3811Z	Collection of non-hazardous waste
	3812Z	Collection of hazardous waste
	3821Z	Treatment and disposal of non-hazardous waste
	3822Z	Treatment and disposal of hazardous waste
	3831Z	Dismantling of wrecks
	3832Z	Recovery of sorted waste
	3900Z	Remediation and other waste management services
	4311Z	Demolition work

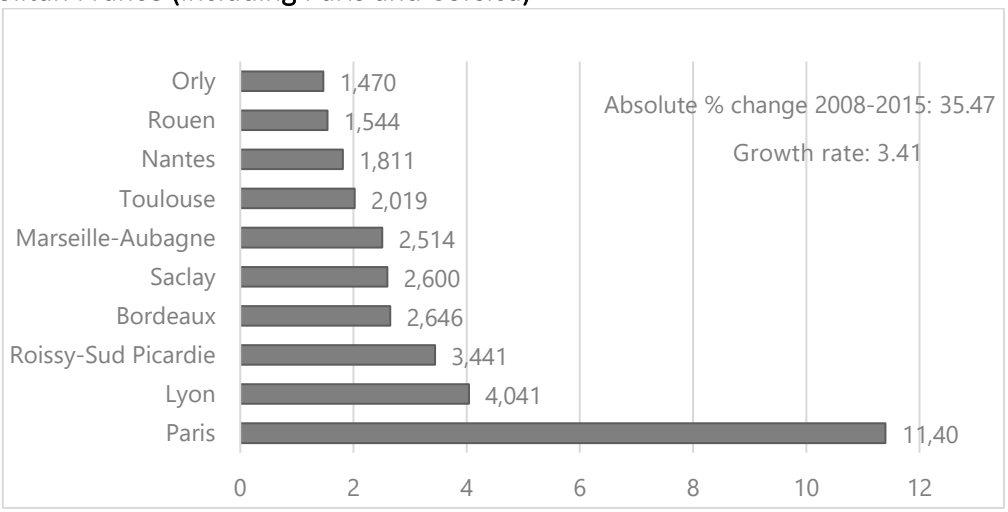
APPENDIX 2: Relative weight of the 20 employment areas with the most circular jobs in metropolitan France (excluding Paris and Corsica)

Employment areas	Weight in circular employment				Evolution			Population density (hbts/km²)
	2008		2015					
	Number	%	Number	%	Number	%	Growth (%)	
Lyon	21850	4,46	23271	4,59	1421	8,11	6,50	578,8
Roissy - South Picardy	17307	3,53	19816	3,91	2509	14,31	14,50	533,7
Coulommiers	14105	2,88	15238	3,00	1133	6,46	8,03	194,2
Saclay	14425	2,94	14952	2,95	527	3,01	3,65	1059,3
Marseille-Aubagne	13855	2,83	14479	2,85	624	3,56	4,50	857,6
Toulouse	11369	2,32	11625	2,29	256	1,46	2,25	167,8
Nantes	10265	2,10	10428	2,06	163	0,93	1,59	221,2
Rouen	8009	1,64	8890	1,75	881	5,03	11,00	194,8
Orly	8809	1,80	8468	1,67	-341	-1,95	-3,87	4221
Grenoble	6903	1,41	7252	1,43	349	1,99	5,06	145
Lille	7476	1,53	7207	1,42	-269	-1,53	-3,60	1222,5
Rennes	7465	1,52	6916	1,36	-549	-3,13	-7,35	148,4
Montpellier	6218	1,27	6757	1,33	539	3,07	8,67	335,9
Strasbourg	6141	1,25	6318	1,25	177	1,01	2,88	685,8
Cergy	3932	0,80	6060	1,19	2128	12,14	54,12	624,8
Clermont-Ferrand	5696	1,16	5929	1,17	233	1,33	4,09	101,9
Nice	6241	1,27	5884	1,16	-357	-2,04	-5,72	181
Le Havre	5113	1,04	5683	1,12	570	3,25	11,15	294
Brest	6196	1,26	5268	1,04	-928	-5,29	-14,98	197,9
Bresle Valley - Vimeu	4961	1,01	5254	1,04	293	1,67	5,91	150,9
Total of the 20 EZs	**186336**	**38,04**	**195695**	**38,57**	**9359**	**53,38**	**5,02**	**12116,5**
Total EC (excluding Paris and Corsica EZ)	**489845**	**100**	**507377**	**100**	**17532**	**100**	**3,58**	**45390,5**

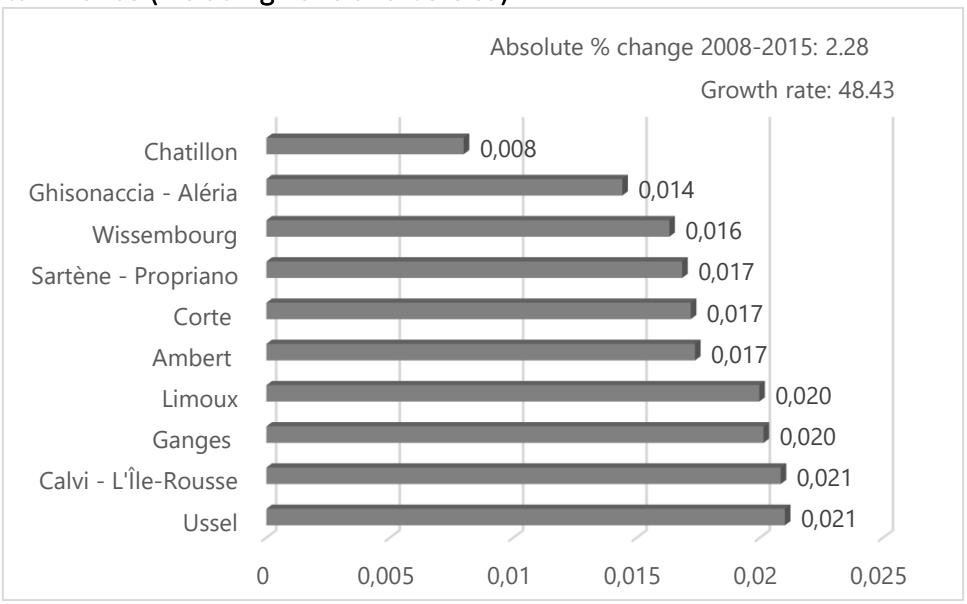
APPENDIX 3: Relative weight of the 10 employment areas with the fewest circular jobs in metropolitan France (excluding Paris and Corsica)

Employment areas	Weight in circular employment				Evolution			Population density (hbts/km²)
	2008		2015					
	Number	%	Number	%	Number	%	Growth (%)	
Le Blanc	130	0,03	167	0,03	37	0,21	28,46	23,8
Autun	181	0,04	157	0,03	-24	-0,14	-13,26	29,7
Avallon	222	0,05	157	0,03	-65	-0,37	-29,28	23,3
Loches	111	0,02	155	0,03	44	0,25	39,64	27,6
Morteau	190	0,04	154	0,03	-36	-0,21	-18,95	70,7
Mauriac	144	0,03	149	0,03	5	0,03	3,47	18,4
Ploërmel	165	0,03	145	0,03	-20	-0,11	-12,12	55,1
Vire	176	0,04	143	0,03	-33	-0,19	-18,75	56,1
Châteaudun	210	0,04	141	0,03	-69	-0,39	-32,86	44
Commercy	102	0,02	137	0,03	35	0,20	34,31	23
Issoudun	136	0,03	134	0,03	-2	-0,01	-1,47	41,2
Saint-Claude	138	0,03	132	0,03	-6	-0,03	-4,35	44,9
Morvan	161	0,03	121	0,02	-40	-0,23	-24,84	12,7
Ussel	177	0,04	121	0,02	-56	-0,32	-31,64	20,3
Marne-la-Vallée	121	0,02	116	0,02	-5	-0,03	-4,13	30,6
Limoux	108	0,02	115	0,02	7	0,04	6,48	24,9
Ambert	120	0,02	100	0,02	-20	-0,11	-16,67	26,4
Wissembourg	71	0,01	94	0,02	23	0,13	32,39	118
Nancy	70	0,01	83	0,02	13	0,07	18,57	18,8
Chatillon	64	0,01	46	0,01	-18	-0,10	-28,13	12,6
Total of the 20 EZs	**2797**	**0,57**	**2567**	**0,51**	**-230**	**-1,31**	**-8,22**	**722,1**
Total EC (excluding Paris and Corsica)	**489845**	**100**	**507377**	**100**	**17532**	**100**	**3,58**	**45390,5**

APPENDIX 4. Relative weights of the 10 employment areas with the most circular jobs in metropolitan France (including Paris and Corsica)



APPENDIX 5. Relative weight of the 10 employment areas with the fewest circular jobs in metropolitan France (including Paris and Corsica)



ANNEXE 6: Methods of calculating statistical indicators

Statistical indices	Statistical entries	Explanations
Employment growth rate	$TxEmp = \frac{Empt + 1 - Empt}{Empt}$	Measures the growth rate of jobs at the place of work (*T x Emp*) between two periods *Empt* and *Empt+1,* corresponding to the evolution of the number of jobs located at the spatial unit level.
Location Coefficient	$LOCZE = \frac{nbreEtsZE}{nbreEtsEC}$	Measures the weight of the establishment in each EZ (*nºEtsZE*) in relation to total employment in the sector (*nºEtsEC*).
Density of establishments	$DEts = \frac{nbreEtsZE}{SZE}$	Obtained by dividing the number of establishments in a spatial unit (*nºEtsZE*) by the surface area of the latter (*SZE*). Thus, it corresponds to the number of establishments per km², which makes it possible to assess the economic attractiveness of the territories.
Moran's I	$I_s = \frac{\sum_{i=1}^{R}\sum_{j=1}^{R} w_{ij}(y_i - \overline{y})(y_j - \overline{y})}{\sum_{i=1}^{R}(y_i - \overline{y})^2}$	The Moran I-statistic measures the spatial distribution of jobs/establishments. With R the number of employment areas, wij the weights of the spatial weighting matrix, yj corresponding here to the density of establishments; s corresponds to the circular activity sectors analysed (EC package, responsible consumption, extension of the life of products and recycling and recovery of waste).