

# RESOURCE

Regional project development assistance  
for the uptake of an Aragonese circular economy

## D5.6 RESOURCE Impact Assessment

Final Version

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Abstract	This document reports how the RESOURCE project activities have contributed to generating scientific knowledge, methodological innovations and new insights related to regional- and knowledge proximity related to circular economy transitions. These scientific insights ( <i>scientific impacts</i> ) of the RESOURCE project provide valuable perspectives for stakeholders involved in circular transitions related



	<p>to i) technology uptake, ii) expertise proximity and iii) cross-regional spillover effects. They also contribute to shaping the landscape for future research linked to circular transitions.</p> <p>Key activities have contributed to better understanding the role of knowledge diffusion for circular activities and transitions through 'hidden' knowledge networks. The results reveal options for fostering the circular transition and offer strategies for reducing the risk. In addition, contributions to gaining more detailed, disaggregated quality data which are essential to better understand and monitor socio-economic and environmental impacts by circular transitions at the macro-economic level have been conducted. Through scientific lenses, this report lays out key insights of RESOURCE. It also highlights opportunities for the region of Aragon.</p>
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## EXECUTIVE SUMMARY

This report explains how the RESOURCE project and its activities have generated scientific knowledge, methodological innovations, and new insights related to regional and knowledge proximity linked to circular economy transitions. The activities have been conducted with a specific focus on the case of Aragon and representant the *scientific impact*. Although the titled 'RESOURCE Impact Assessment', this report does not evaluate the project's implementation, management performance or administrative efficiency, as could be anticipated. This report, in line with RESOURCE proposal, focusses on aggregated socio-economic and environmental impacts of the circular innovations identified in the project. Within the RESOURCE project valuable outcomes have been produced that contributed to refining scientific knowledge linked to regional circular transitions. This report also explores how RESOURCE has contributed to advancing research and practical knowledge that can guide future circular economy transition policies and investment strategies.

Key activities have contributed to better understanding the role of knowledge diffusion for circular activities and transitions through 'hidden' knowledge networks. The results reveal options for fostering the circular transition and offer strategies for reducing the risk of knowledge bottlenecks. In addition, valuable contributions to gaining more detailed, disaggregated quality data which are essential to better understand socio-economic and environmental impacts by circular transitions at the macro-economic level have been conducted. Through scientific lenses, this report lays out key insights of RESOURCE. It also highlights opportunities for the region of Aragon.

The RESOURCE project operated within Aragon's strategic framework for circular economy transition, building upon the region's 2020 Circular Strategy that aims to position circular economy as a key economic sector by 2030. Aragon's diverse industrial structure, spanning manufacturing, agri-food, automotive, and chemical sectors, provided a solid foundation for implementing circular economy principles across multiple domains.

In particular, the analyses presented in this deliverable reflect three complementary dimensions of RESOURCE's contribution, each highlighting a different aspect of its impact:

- Scientific dimension: We advance knowledge on regional circular economy innovation dynamics by utilising original patent and trademark data across OECD and European regions. The analysis identifies how innovation develops and diffuses spatially through knowledge-intensive business service networks.
- Methodological dimension: We develop tools to disaggregate Spanish Input–Output data to the NUTS-3 level and to integrate firm-network information into regional impact modelling. This approach provides a replicable analytical framework that can be applied in other regions and to other cases.

- Regional dimension: We apply these methods to the case of Aragon, RESOURCE's focal region. The results generate insights that support local policy and investment decisions aimed at strengthening the regional circular economy.

#### Key highlights for Aragon

The project contributes to quantifying the role of knowledge intensive business services (KIBS) in facilitating circular economy innovation across both technological and non-technological dimensions. Through a comprehensive analysis of patent and trademark data, the research reveals that regions with strong KIBS firm networks show significantly higher levels of circular economy innovation activities. The region of Aragon illustrates an observed regional heterogeneity pattern. Within the region, Zaragoza emerged as a notable example, registering 21 circular economy related patents and 26 trademarks, compared with only 2 patents and 1 trademark in Huesca, and none in Teruel.

Within the RESOURCE project, an innovative approach to mapping regional economic connections by creating a disaggregated Multi-Regional Input-Output (MRIO) table for Spain at NUTS-3 level was developed. This methodology incorporates intra-firm linkages and knowledge networks rather than relying solely on traditional geographical or sectoral approaches. The resulting 59-region, 64-sector model enables advanced simulation of circular economy interventions and their measuring cross-regional impacts, addressing a significant gap in existing analytical tools. Simulations show that the region of Aragon has strong connection with Madrid and Barcelona, as well as other regions. Conversely, productivity improvements in circular sectors can create negative impacts in other regions due to reduced input demand, illustrating the complex interdependencies within circular economy transitions.

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## ABBREVIATIONS

Abbreviations	Meaning
APS	Advanced Producer Service
CE	Circular economy
IO	Input-Output (table)
KIBS	Knowledge Intensive Business Services
KPIs	Key Performance Indicators
LCA	Life Cycle Assessment
MRIO	Multi-Regional Input-Output (table)
PDA	Project Development Assistance
WP	Work Package

# 1 Introduction

## 1.1. Context and background

The RESOURCE project is studying the private funding opportunities needed in circular projects and facilitating their development. RESOURCE's overarching objective is to develop new Project Development Assistance (PDA) services to fund regional circular economy (CE) investment projects. More precisely RESOURCE is:

- building an integrated expertise pool to support technically, economically, and legally the regional CE pilots SMEs,
- developing innovative financing schemes and business models,
- launching concrete investments.

The methodology developed for the RESOURCE project ensures the sustainability of those CE projects by potentially completing their private funding with other sources of financing (European, national, and regional public funds).

The RESOURCE methodology consists of seven steps:



Figure 1 - The RESOURCE methodology in 7 steps

The strong interest coming from Aragon companies to shift towards circular practices should guarantee a sustainable pipeline of projects to test the RESOURCE methodology. The final and overall objective of the RESOURCE project through the creation of a portfolio of project development assistance services, is to accelerate the development of the CE in Aragon and to reach €20M direct investment in circular projects over a period of 36 months, until end of June 2025.

RESOURCE is particularly **reaching out to and gathering a CE community to develop an innovative regional process and ecosystem** to remove the technical, economic, legal,

regulatory, and financial barriers the CE projects face, ensuring the replicability of its PDA services and maximise their impact both in Aragon (Spain) and beyond.

## 1.2. Scope

This document investigates and reveals how the insights gained through the RESOURCE project due to partner collaboration, exchange with the pilots and the governmental contacts shaped associated research and offer valuable lessons for future attempts to turn towards circularity. Furthermore, this document elaborates on the promising options and considerations for the Region of Aragon to proceed towards more circular economic activities.

This report explains how the RESOURCE project and its activities have generated scientific knowledge, methodological innovations, and new insights related to regional and knowledge proximity linked to circular economy transitions. The activities have been conducted with a specific focus on the case of Aragon and representant the scientific impact. Although the titled 'RESOURCE Impact Assessment', this report does not evaluate the project's implementation, management performance or administrative efficiency, as could be anticipated. This report, in line with RESOURCE proposal focusses on aggregated socio-economic and environmental impacts of the circular innovations identified in the project. Within the RESOURCE project valuable outcomes have been produced that contributed to refining scientific knowledge linked to circular transitions. This report also explores how RESOURCE has contributed to advancing research and practical knowledge that can guide future circular economy transition policies and investment strategies.

## 1.3. Structure of the document

The document is structured as follows. We begin with recapitulating the lessons learned, also from within previous WPs. We elaborate on the role of knowledge awareness and diffusion, also with respect to the exchange with pilots.

We then elaborate on the scientific contributions conducted within the RESOURCE project and how the insights advance the understanding of facilitating circular transitions. The scientific activities in RESOURCE focus on i) assessing circular transition potentials, ii) generate required data and iii) understand knowledge diffusion.

We then discuss and conclude how all these insights offer opportunities for future research or indication for how politicians can progress.

In particular, the analyses presented in this deliverable reflect three complementary dimensions of RESOURCE's contribution, highlighting different aspects of its impact:

- Scientific dimension: We advance knowledge on regional circular economy innovation dynamics by utilising original patent and trademark data across OECD and European regions. The analysis identifies how innovation develops and diffuses spatially through knowledge-intensive business service networks.

- Methodological dimension: We develop tools to disaggregate Spanish Input–Output data to the NUTS-3 level and to integrate firm-network information into regional impact modelling. This approach provides a replicable analytical framework that can be applied in other regions.
- Regional dimension: We apply these methods to the case of Aragon, RESOURCE’s focal region. The results generate insights that support local policy and investment decisions aimed at strengthening the regional circular economy.

## 1.4. Links with other components of RESOURCE

This deliverable builds upon other RESOURCE work packages and exchange with RESOURCE consortium partners. Relevant inputs came from **WP1** (Stakeholder Mapping and Engagement) and **WP4** (Circular Economy Practice mapping).

**D1.1** of **WP1** qualitatively identifies the key stakeholder groups being involved or contributing to driving progress in circular economy transitions. These include inter alia public institutions, intermediary organizations, business networks, regional cluster, regional institutions financial stakeholders and beneficiaries. The report in particular highlighted the role of intermediaries in linking firms, expertise and knowledge, as well as financial resources, public institutions and regional circular innovation systems.

**D4.1** of **WP4** maps and assesses successful circular projects across Europe. It derives key pillars of successful profiles, which are access to funding components, capacity building and training to enhance skills and knowledge, networking and collaborations to connect within circular ecosystems, technical support and policy, advocacy and regulatory frameworks. These five pillars were further explored in **D4.2** assessing related subdimensions through Best Practice Sharing Sessions. For instance, best practices identified refer to dimensions of such as tailored knowledge exchange, access to funding or cross-sector collaboration.

**D5.6** analyses these relationships and quantitatively explores how KIBS networks contribute to the generation and diffusion of circular knowledge and innovation. This is done by using corporate network data together with original patent and trademark data. We trace patterns of knowledge exchange and collaboration among firms and intermediaries, showing how the presence and connectivity of KIBS actors enhance regional innovation outcomes. It in addition the role of directionality in knowledge networks is quantified. The outcomes of the analysis provide evidence for the qualitatively identified structures and relations in D1.1, D4.1 and D4.2, demonstrating how intermediary organizations act as catalyser for institutional collaboration and influence circular economy innovation performance. Therefore **D5.6 complements the previous results** demonstrating through data-driven regional analysis and modelling how enabling conditions operate in practice at regional scales and even lead to positive spill-over effects.

The research progress, first results and final outcomes were presented and communicated to partners within consortium meetings and sparked interests. Due to the final due date, there was little feedback into previous deliverables. The results are nevertheless relevant for the

local partners within the region of Aragon, such as GoA, ANCES and CEEI to be anticipate current factors and work toward steering circular conditions.

## 2 Challenge and starting situation

The region of Aragon has significant potential for transitioning towards a more circular economy due to a diverse structure and its natural resources. Its relative specialization lies within the manufacturing industry and the agri-food sector. Key activities within the industrial sector are associated with the automobile industry, metallurgy, machinery, chemical and pharmaceuticals. In addition, the region has the ambition to strive for being a frontrunner within this field of transition. The government of Aragon has demonstrated a continuous commitment through providing incentives, support and shaping regulations that foster sustainable economic activities across sectors and stakeholders. Notable actions include the development of a circular economic strategy, granting support for circular business models, facilitating partnerships between business, research institutions and public entities. Furthermore, promoting circular procurement practices, organization of workshops and training programs are to be mentioned. These activities also contributed to the viability of the RESOURCE project (Myrdinas et al., 2023).

A more detailed description can be found in the deliverable D1.1 (Fernández et al., 2022).

The government of Aragon has amended the Aragon Circular Strategy in January 2020. The objectives covered in the strategy plan provide a vision for becoming more circular by 2030 are as follows (see Myrdinas et al., 2023).

- Incentivize economic activity and employment generation in Circular Economy in Aragon.
- Promote the circular economy sector as a strategic economic sector in Aragon as a dynamic and driving force for the economic and social development of the autonomous community.
- Promote entrepreneurship in the new niches of activity derived from the Circular Economy, as well as intra-entrepreneurship in existing innovative companies.
- Recognize and enhance the value of leading companies in the transition to the new economic model.
- Positioning the circular economy as a strategic sector in the economic panorama of Aragon.
- Promote specialization in the sector.

The RESOURCE project assessing and exploring the private funding opportunities needed in circular project and facilitating their developments assessed, studied and supported different pilot projects in their economic, social, knowledge and legal sphere. It also explored relevant connections and conditions in the region of Aragon over the 36 months of the project being.

From a scientific perspective the question becomes relevant on how do the insights gained over the period help identifying opportunities and risks for a circularity transition in Aragon? How have the insights contributed to the research landscape? In other words, what is the impact that the project did on the scientific sphere.

## 2.1 Insights gained through other WP

Since the beginning of the project, through the exchanges with pilots and stakeholders, as well through WP1 and WP4, it became clear how important connections on different dimension for successful circular startups are. These connections operate at two main levels. First, there are relevant connections within the circular ecosystem, i.e., the region of Aragon and knowledge pools; and second, there are superior networks, in which knowledge exchange and resource provision take place. As indicated in Section 1.4. there had been qualitative evidence for an underlying relevance of intermediaries in supporting circular successes. Understanding the relevance quantitative within the network of economic transactions, spatial and knowledge relations became a key to enable targeted project development insights. In addition, it became clear through WP1 and WP2 that different types of expertise are essentials in parallel, such financial, economic, legal, technical and sustainable support and expertise.

It must be noted that, for each needed sub dimension, expertise related to CE activities go beyond traditional, linear business approaches, as they need to be considered simultaneously. This is because the connections, the production niche and the innovative business models are frequently not generalizable but settled in the specific context of a region and the context of a circular business model (Ding et al. 2023). A key feature for circularity is the additional interaction of actors at the local level and in the local ecosphere, as it is important to understand what kind of opportunities are present, e.g., which waste flows could be re-used or re-directed and which circular strategy to apply (Kirchherr et al. 2017).

In addition, a Life Cycle Assessment (LCA) hotspot analysis for pilot projects, was conducted within WP2. The tasks revealed that for pilot production activities the largest impacts, the contributing processes and whenever possible explored how specific changes could contribute to overall impact reductions (see Myridinas et al., 2023). It also highlights the importance of understanding supply chains and macro-economic connections in full detail.

Consequently, for a better, more comprehensive and detailed overall assessment, an advanced understanding of what is flowing into a region (commodities) and flowing out (commodities) is needed. The overall assessments are limited by the available dataset, regional or national accounting standards and data flows available through bookkeeping by companies. It became clear that i) a better understanding of how knowledge flows and enables circular transitions is needed and ii) existing databases need to be improved at their level of detail and connections.

## 2.2 The role of access knowledge and knowledge networks

Given the interaction of actors, industries and perspectives for the success of circular transition, we anticipate that the component of knowledge, expertise and mutual connection plays a key role. This is a feature was also recognized while assessing what is important for successful investments. **In many cases investors wanted to see expertise embodied in the HR of a company.** Through conducting the best-practise assessment (Abdallah & Baumberger, 2024) we realized that for more successful approaches in regions, cities and municipalities access to circular expert knowledge is required on the company side, as well as on the governmental side.

Therefore, a pressing question raises: **What determines the diffusion of circular knowledge, what makes it accessible and how is the region of Aragon being placed in global knowledge networks?** We recognised that this topic has been under researched. There has been literature on green patents (Rainville et al., 2025), technology diffusion through networks (Zhang et al., 2024) and the role of KIBS networks for the diffusion of knowledge (Pain et al., 2024; Taylor et al., 2014), but these have not been applied in the context of circular knowledge.

Within the RESOURCE project we contribute to the literature on **the role of hidden and relevant “circular knowledge” networks** created by KIBS firms that facilitate the diffusion of related technologies. We approach in a first manuscript how the knowledge network influences regional circular patenting landscape (Zhang et al., 2025a) and in a second (Zhang et al., 2025b) how the knowledge network influences the regional non-technical innovation using trademark data (Abbasiharofteh et al., 2022).

## 2.3 The role of knowledge intensive business services (KIBS) for regional circular economy innovation (CEI)

What makes CEI so special and distinct from classical innovation is that **CEI represents a system transformation.** Hence, knowing a technology is insufficient. A related transition **requires ultimately the reconfiguration of entire products and consumption systems**, having implications for systems of supply chains. An isolated innovation of single components is therefore insufficient (Audretsch & Fiedler, 2024). This is also reflected in the literature on preconditions, where it is highlighted that CEI requires synthetic knowledge, integrating diverse types of expertise and skills across sectors that goes even beyond requirements for green innovation (Van Luu & Chromjaková, 2024). In addition, the skillset of circular economies appears to be different to established economic activities (Buyukyazici & Quatraro, 2025). Instead of focusing on improving resource efficiency or developing alternatives, **CEI**

**emphasizes retaining materials within the system or closed loops, driven by principles such as reduce, reuse and recycle** (D'amato & Korhonen, 2021). Beyond these characteristics, CEI is highly collaborative, requiring exchange across stakeholders, skills and both tangible and intangible resources (Kanda et al., 2025). Intermediaries play a crucial role in facilitating this process (Dey et al., 2022).

Within the literature on innovation, **APS firms**, a specialized subset of KIBS firms, operating in sectors such as banking, law, management consultancy, accountancy, and advertising are increasingly recognized as important intermediaries (Pereira & Vence, 2021). These firms **provide specialized expertise**, which is not constant required on the demand side of actors and therefore **not employed on a regular basis**. However, this specialized knowledge benefits business and governmental activities if a robust KIBS presence is existent (van Meeteren & Bassens, 2024). A second benefit is that the **KIBS presence can contribute to bridge cognitive distances between co-located industrial clusters**. Often the capability to translate and contextualize different disciplinary languages or insights facilitates progress (Nootboom, 2000) – a feature we have **also seen within RESOURCE, where at the beginning a common language among partners from different sectors had to be established**. KIBS firms can claim this role, enabling cross-sectoral learning and knowledge flows (Kano et al., 2020). However, KIBS firms, especially the multi-locational ones, are not operating isolated. They have a global network that facilitates the connection beyond spatial boundaries and across technologies (Pain et al., 2024).

Within the process of innovation in many cases a combination of different ideas (Weitzman, 1998) or a combination of local and external knowledge fuels successful outcomes. Existing research focusses on intra-regional perspectives, neglecting the role of exterior extra-regional linkages. It has nevertheless been identified in the literature that transnational networks facilitate the circulation of expertise (van Meeteren & Bassens, 2024).

**In a globalized world economy KIBS**, such as consultancy on legal, technological or financial issues provide knowledge exchange and **could, because they facilitate the recombination of ideas, potentially serve as a driver of innovation**. To assess this research question, we analysed within the RESOURCE project patent data from 2000-2023 across 1,761 TL3-level regions in 38 OECD countries. We use a keyword search approach to identify innovations linked to the six categories *reduce, recycle, reuse, recover, solid waste management and wastewater management*. The dataset was further refined for redundancy and patents that have the required geographical details. Finally, **a total of 34,033 unique patents granted between 2000 and 2023 attributed to 82,071 inventors across 1,418 OECD TL3 regions in 38 OECD countries were considered**.

We construct a company network using the global top 100 APS firms, a specialized subset of KIBS firms. The links of the network consider intra-firm headquarter-subsidary relations. The APS firms consist of 50 *banking and financial service*, 15 *law*, 15 *advertisement*, 10 *accountancy and 10 management consultancy* firms.

We use this network to conduct a spatial econometric analysis assessing the importance of different network measures. Measures we use are centrality, indegree, outdegree, eigenvector and betweenness. We find that the *weighted indegree, measuring the connections coming from KIBS headquarters reflecting, a region's capacity to attract subsidiaries* is positive and significant, indicating that **hosting branches provides access to external knowledge, technologies and innovative approaches supporting CEI within the corresponding region**. We also find that the *weighted outdegree* is positive and significant. Hence, **hosting headquarters that represent knowledge hubs provides an advantage for CEI**. Furthermore, *betweenness and eigenvector centrality* indicate that a **structural integration within the KIBS network gives strategic advantages**. These measures represent the connectivity to (most) influential regions (eigenvector) and the number of shortest paths of the network structure connecting any two regions running through the assessed region (betweenness).

In a second, but similar approach **we explored the importance of KIBS firm networks for Circular business model innovations (CBM) using the trademark dataset as reference**. CBMs refer to how firms create, capture, and deliver value by optimizing material flows in line with CE principles (Lüdeke-Freund, 2020). Unlike traditional models based on the linear “take-make-dispose” logic, CBMs aim to extend product lifespans, regenerate natural systems, and minimize waste (De Angelis, 2022; Kirchherr et al., 2023). Existing studies majorly focus on science and technology-based outputs, however frequently overlooking non technological circular business model (CBM) innovation. The more commonly investigated technology-based innovation (STI) is rooted in formal R&D approaches, triggering new products and processes. The related and called material-technical loops are primarily linked to STI reflecting engineered processes and technologies. There is however another relevant dimension of innovation existent, the sphere of Doing-Using-Interaction (DUI), which relates to experimental learning, practice-based problem solving and user feedback, contributing to commercial, organization and service-based innovations. This side refers to product-service and social-collaborative loops, which are aligned with DUI dynamics. Nonetheless regional specific research on CBM innovation has largely focused on techno-centric STI patent-based quantification. Such approaches miss potentially highly relevant CBM innovations and adjustments, specifically in rural, downstream or peripheral (regional) context, where the formal R&D research capacity is limited (Breznitz, 2021; Tödting et al., 2020).

The underlying analysis assessing relations within the **trademark database linked to KIBS firm network is based on patent and trademark data from 1,479 NUTS-3 regions across 34 European countries**. The network is again constructed from the top 100 KIBS firms. Our dependent variable is the number of CE-related trademark applications per NUTS-3 region. The period we are considering is 1996 to 2020. Our hypotheses postulate that regions revealing a strong embeddedness within the KIBS firm networks are more likely to develop DUI driven CBM innovations and that the influence of the network extends beyond the direct connection. This implies that also a neighbouring region through strong connections with the

KIBS network can facilitate stronger innovations. The second hypothesis considers mobility that is not directly visible from the data. If for instance a company has an office in Madrid it is possible that expertise could be provided for Zaragoza or Huesca.

The spatial distribution of CE related trademarks is uneven. What we see is that **next to classical hubs, the region of Zaragoza is relatively prominent, underlying its overall advancement linked to circular activities**. Zaragoza reveals a total 26 CE Trademark registrations, while Huesca has 1 and Teruel 0. If we had considered 'green' Trademark registrations numbers would be 79, 18 and 1 respectively. In total numbers Madrid, Barcelona and Valencia are most prominent. On the other side, i.e. the network measures, as visualized below with total network degreed, we see that the capital region in Spain, i.e. Madrid and Cantabria have the strongest network measures related to KIBS firms.

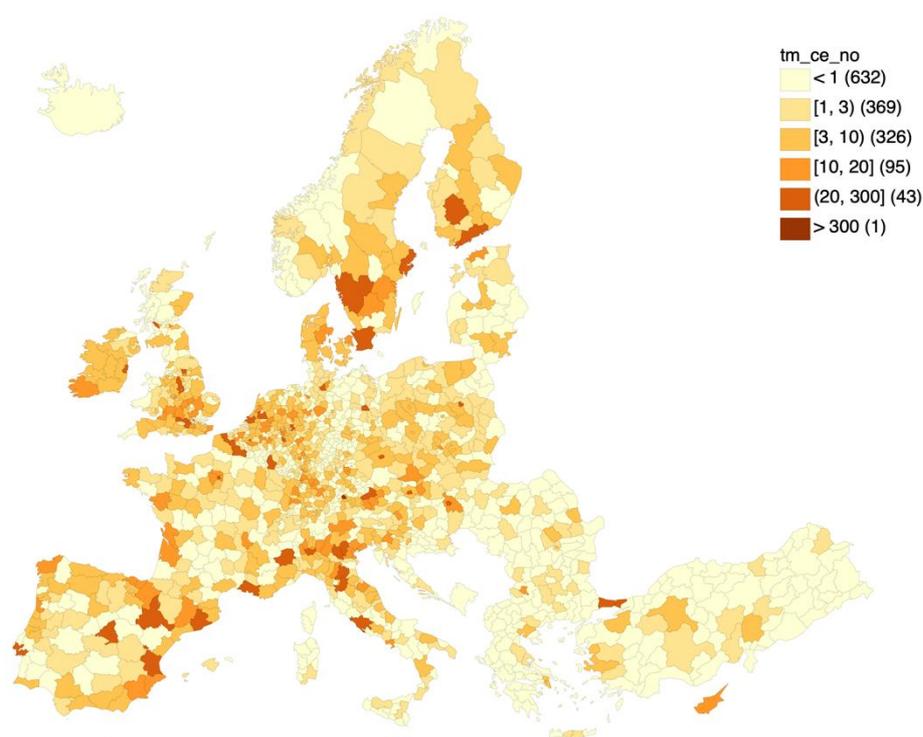


Figure 2: Spatial distribution of total CE-related trademarks across 1,465 NUTS3 regions of Zhang et al. (2025b)

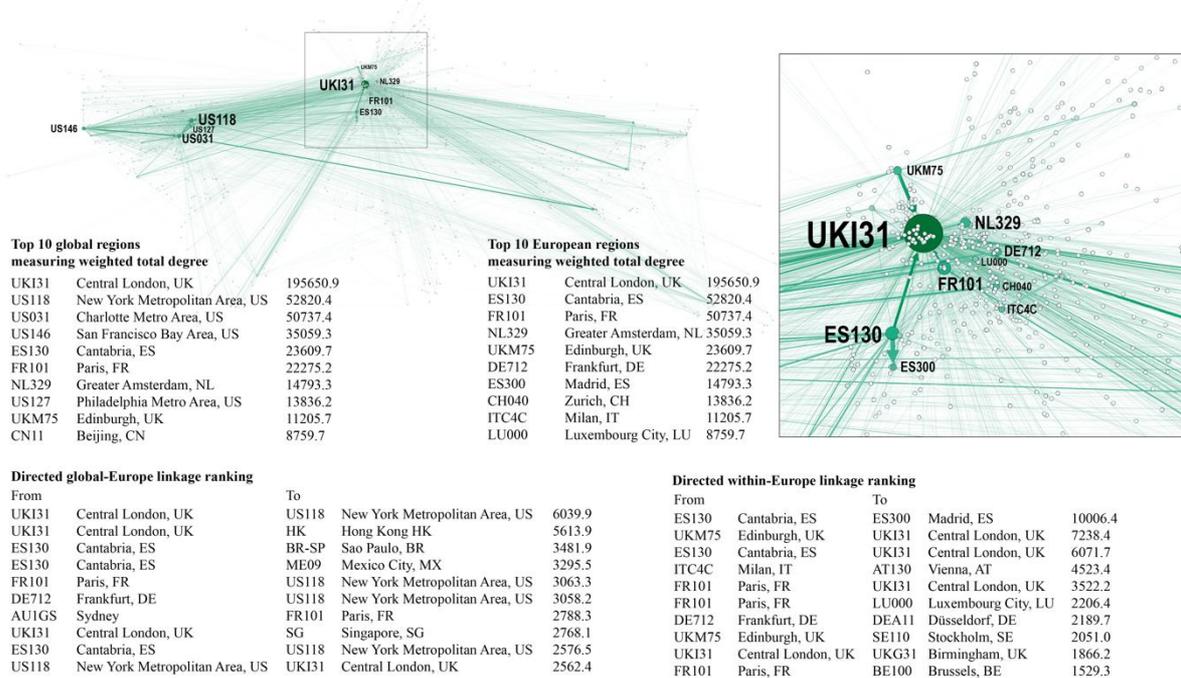


Figure 3 KIBS firm networks using weighted total degree centrality from Zhang et al. (2025b)

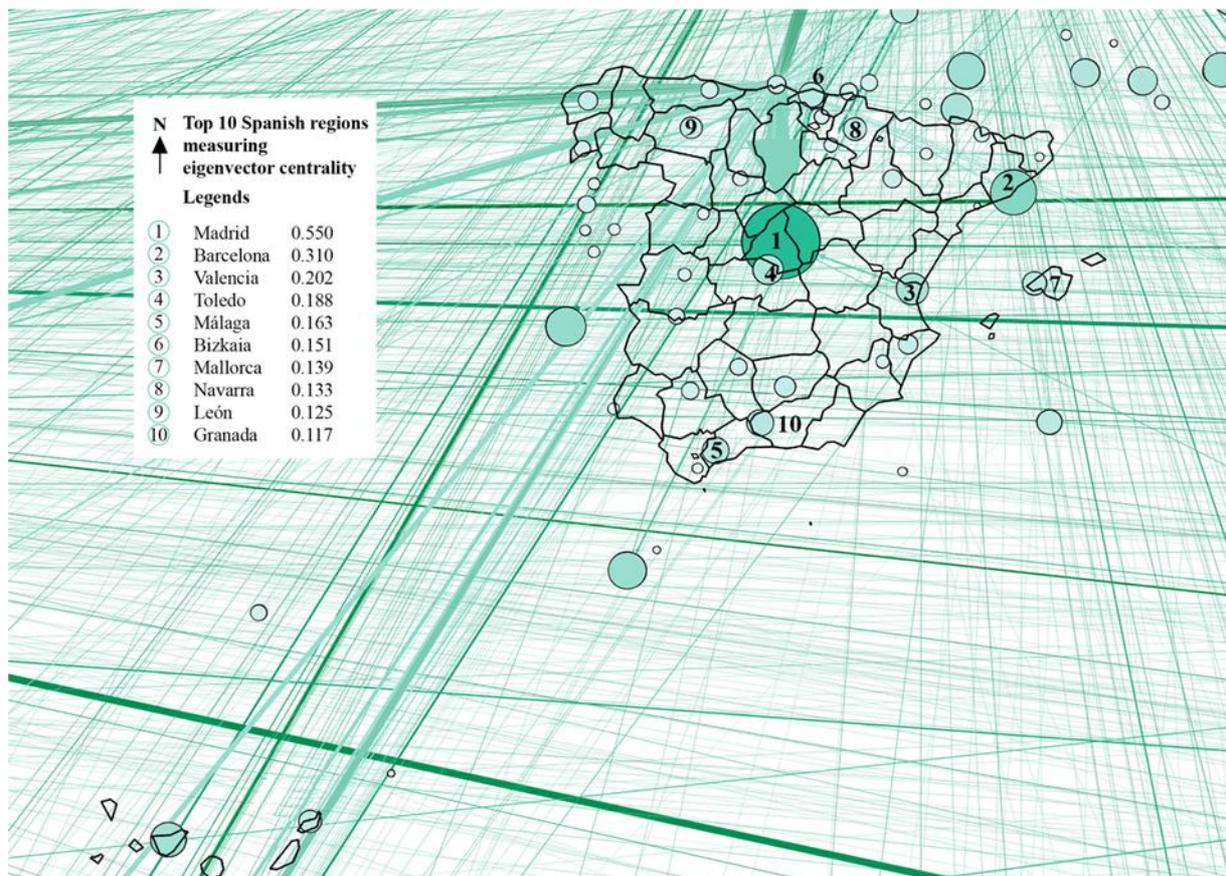


Figure 4 KIBS firm networks using weighted total degree centrality focusing on Spain from Zhang & Ward (2025)

Our results show that the weighted indegree, to a lesser extent the weighted outdegree, the eigenvector and the betweenness show robust, positive and significant influence on the registration of trademark items related to CE. This implies they are supporting innovation. In addition, **these outcomes show for the first time that regions on the dimension of circular innovation also do benefit from the proximity within the KIBS networks to other regions**, a measure called closeness centrality measure, which measures how easily a region can access all other regions in the network.

## 2.4 Strategies to assess the potentials of more circular economies

A second component of scientific relevance is to understand and estimate environmental and socio-economic potentials of transitions (Aguilar Hernandez et al., 2020). Recent methods to anticipate quantify overall impacts of circular transition are being based on Multi-Regional Input-Output (MRIO) analysis (Donati et al., 2020) and have been conducted at an aggregated level (e.g. at the national level). However, as seen in the project, in case of circular transitions the regional relations and the more local economic habitat become relevant. In principle the most promising way is to apply or produce highly disaggregated MRIO data. Ideally the underlying data is available at the regional level with environmental impact data. This would enable a simulation of the impacts of adopting more circular practices. The underlying idea is that the current observed economic network structure is modified to depict changes triggered by modification, transitions or in our case more circular practices adaptations. The best quality of data can be achieved through collection, which is however time and resource intensive.

However, in case of Aragon a detailed and disaggregated dataset has still been missing. (Zhang & Ward, 2025) This situation on the other side offers opportunities for contributing to the research landscape. **Within the RESOURCE project we contributed to the literature by developing an advanced disaggregation methodology, building on company network relations.**

## 2.5 Knowledge networks in sub-national networks

For an overall assessment of how transitions will impact supply chains and value added, it is important to anticipate how territories, provinces and sectors are connected. While national-level IO tables are frequently used to derive policy impact predictions or inform policies on consequences of global disruptions or shifts (Zhong and Pei, 2022), they do not allow to assess impacts at the subnational levels. They also do not enable scientists to account for sector and economic heterogeneity at the sub-national level. MRIO and IO are data and time intensive in construction (Torj, 2024b). **For most countries a sub-national MRIO with high sectoral and regional resolution is not existent.** Usually, due to high costs and administration of collecting underlying data and combining these to MRIO most frequently used construction methods for MRIOs are relying on non-survey approaches. These methods include Location Quotient

approaches (Flegg et al., 1995), gravity-based approaches (Lindall et al., 2006), approaches considering economic activities, proximity or spatial economic approaches (Rey, 2000, Toroj 2024a).

These approaches however neglect the fact that **there is a tendency for more fragmented global supply chains through firm-level and intra-corporate networks** (Jones & Kierzkowski, 2005; Hewings & Oosterhaven, 2021). Specifically, when considering **circular economic transitions, the relations between firms, the embodied knowledge flows and specific regional connections are of high importance**. In addition, intra-firm relations are of relevance for production and trade flows (Zhang et al 2024). Globally, there is a development that production and sourcing decisions are increasingly governed internally within firms and their networks than through market-based transitions (Bresnahan & Levin, 2012)

## 2.6 An innovative approach to decompose IOs and simulating impacts of (circular) transitions

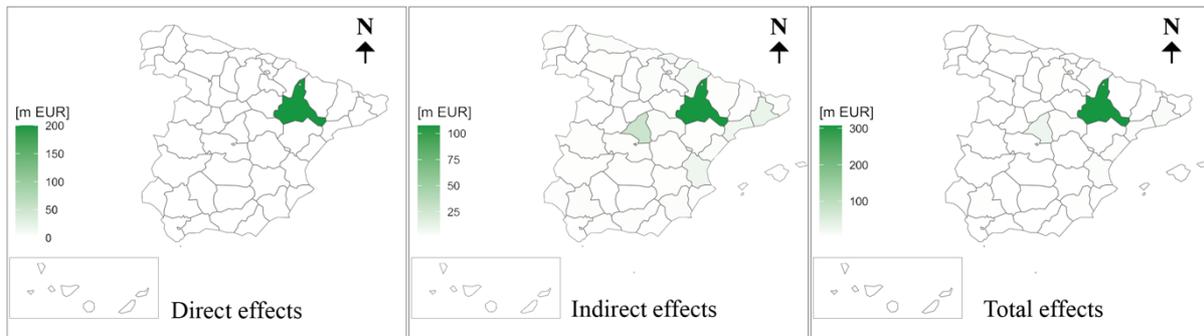
Within the RESOURCE project we have developed an innovative technique allowing construct MRIO tables with a more detailed regional resolution incorporating the information by KIBS firm relations. To split IO data or MRIO data into smaller entities making explicit use of underlying economic knowledge network we use the circular knowledge networks as described in previous sections (Zhang et al., 2025 a; b; Zhang, 2024), but with a focus on Spain. Our approach uses three different layers of information, combining measured intra-firm linkages, geographical distance and economic similarity. With a Bayesian spatial economic framework, we decompose a national Spanish IO table to a MRIO at the NUTS-3 level with, inter alia accounting for the single regions of Aragon, i.e. Zaragoza, Teruel and Huesca. The basis forms the most recent Spanish full national IO table from the Spanish National Statistics Institute (INE) for the year 2020, which has a sectoral resolution of 64 sectors. In addition, we use Gross Value-Added (GVA) data at the NUTS-3 level for 59 Spanish regions from Eurostat, which are reported at seven NACE Rev. 2 sectoral aggregates. We use our derived organizational proximity network constructed of 22,585 global intra-firm ownership links of which 15,086 are intra-national within Spain. The network has concentrated hubs in Madrid, Barcelona and Bilbao and serves as input into the spatial econometric model, capturing regional independencies that are insufficiently explained by geography alone.

We end up with an MRIO consisting of 59 regions and 64 sectors. We exploit our newly generated data for first simulation approaches, depicting circular adjustments.

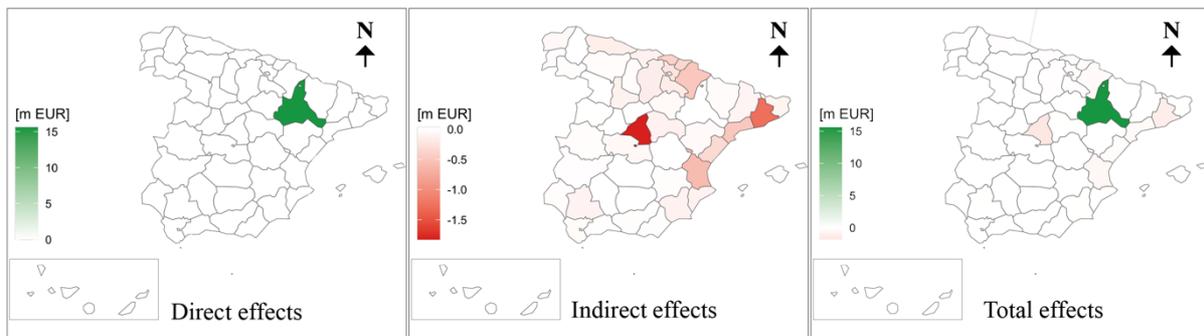
We conceptualize three simulation showing how different economic adjustments would diffuse through the structure and how different types of adjustments trigger qualitative differences in outcomes.

A first scenario looking that a hypothetical demand-side stimulus, i.e. a localized green investment in the Sector *Sewerage services; sewage sludge; waste collection, treatment and disposal services; materials recovery* in the region of Zaragoza with an amount of €200 million in revenue and €100 million in intermediate input costs reveals the following. The €200 million

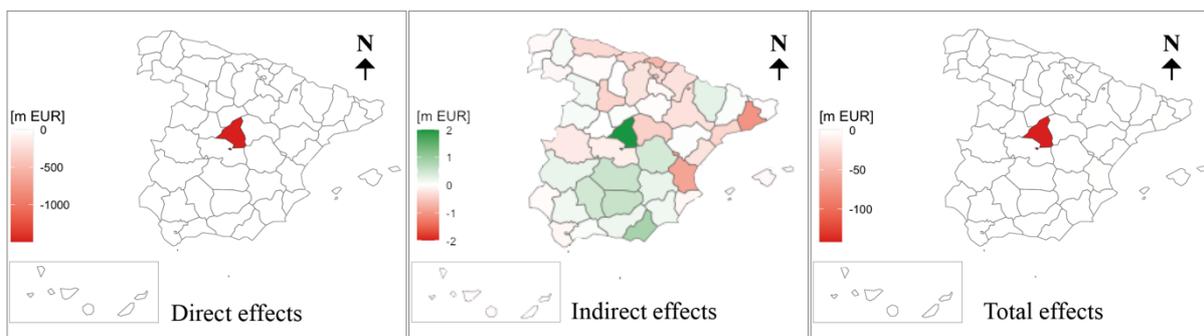
output gain in Zaragoza would trigger €108 million of indirect outputs in the same region and additional other gains across regions. The trans-regional spill overs would be substantial, as Madrid would gain €27.6 million, Barcelona €11.5 million, Valencia €8.5 million and Tarragona €8.0 million. The findings are shown in Figure 5.



Simulation scenario 1: Green stimulus in Zaragoza, Sector 26.



Simulation scenario 2: Simulation scenario: Green stimulus in Zaragoza, Sector 26.



Simulation scenario 3: Simulation scenario: Demand-side contraction in Madrid, Sector 36.

Figure 5 taken from Zhang & Ward (2025) *Impact of different circular adjustments diffusing through the decomposed sub-national MRIO of Spain*

In a second scenario, we simulate a supply side productivity boost. For this scenario we assume a hypothetical productivity improvement of the sector Sewerage services; sewage sludge; waste collection, treatment and disposal services; materials recovery in the region of Zaragoza. We assume a 20% increase in productivity. This implies that the sector could now produce the same level of output requiring only 80% of the previous inputs. In this case the region of Zaragoza would gain €15.6 million, which corresponds to the output increases in the

more productive sector. Indirectly other regions are negatively impacted, which are most prominently Madrid (-€1.8m), Barcelona (-€1.3m) and Valencia (-€0.6m). These impacts occur because Zaragoza's economy needs less inputs, which diffuse through the network and translate to lower demand for intermediate goods from other regions.

To further explore the mutual connections of economic activities at the subnational level, we explore a non-circular related scenario. We assume as hypothesis that there is a shock impacted the tourism economy in Madrid, similar to a regionally restricted Covid shock. We assume a 10% decline for the sector *Accommodation and food services*. This shock would translate to a direct output loss off €1,498 million for the capital region.

Interestingly, this is partially set off as we identify €1,356 millions of indirect effects. These effects are likewise caused by upstream adjustments within Madrid's production network. When final demand for sector *Accommodation and food services*, firm actors in that sector reduce their purchases of intermediate goods and services (such as food supplies, laundry, cleaning, local logistics, etc.). In the IO framework, this triggers a cascade of demand adjustments for suppliers in connected sectors. However, because these suppliers also consume inputs from other local firms, their contraction may free up resources that are then reabsorbed by other sectors within Madrid. There is a diverse picture of impacts across Spanish regions. In this case there would be slightly negative effects for the region of Zaragoza. Some regions south of Madrid would gain modest increases in outputs.

## 2.7 Zooming into aggregated product categories

Within the RESOURCE project we conducted research on further exploring underlying structures of aggregated input-output sectors. We did so by not directly assessing MRIO data, but by diving into the UN Comtrade database, which is frequently used for constructing MRIO data, see e.g. (Timmer et al., 2015; Aguiar et al., 2019). We approach this line of research analysing relationships across mutually reported trade flows. It had been identified earlier that for instance for plastics several types are likewise aggregated into single traded categories, making an anticipation of sectors, sectoral relevance and environmental impacts assessment difficult (Li, 2025). Consequentially these deficits are also inherited to the constructed MRIOs and need to be overcome when aiming for higher sectoral resolution or conceptualizing ex-ante assessments of transitions to more circular economies.

The methodology identified in the RESOURCE project allows to distinguish sectors where likely only one product or product categories is present from categories where several different sub-items are present (Li et al., 2025). These results help indicating where researchers should be cautious with aggregated assumptions and future disaggregation processes are required.

## 3 Shaping future research

The insights gained from the scientific research conducted within the RESOURCE project open the road towards future contributions.

We contributed to the field of the **importance of knowledge networks provided by KIBS firms for the diffusion and creation of circular technologies**. We did so at a generalized circular level. However, **the question remains whether the network has different levels of relevance for specific underlying circularity dimensions and business cases**. It might be that companies and technologies focussing on recovering benefit to a different extent than companies or technologies specializing on recycle, redesign or remanufacturing. It has also not been assessed **whether specific sub-dimensions of KIBS firms**, such as financial support or juristically **support serve different knowledge diffusion capabilities**.

**RESOURCE has contributed with assessing hidden structure in trade data**, which has implications for the future construction and research of MRIO models. Many models are based on publicly available trade and relation data. In many cases trade data, such as Comtrade serves as underlying calibration unit (Timmer et al., 2015; Aguiar et al., 2019). The hidden structures, where probably several different products and sectors are involved give a guidance to researchers on where to refine sectoral resolutions. In addition, RESOURCE has contributed to **using the hidden value of company networks for generating better data structures**. These insights (can) serve as openers of new field of research and new methods of data provision.

Also, the items we could not successfully solve, such as disaggregating emission data in parallel to disaggregating (MR)IOs to higher sectoral resolutions will influence our and other scientist future work.

Within D2.1. it had been identified that key leverages across several pilots to reduce impacts are striving for reduced transport distances, adjusting transport modes, improving waste management systems and switching to circular, i.e. renewable energy supply. It will be interesting for future research to assess in how far these patterns hold for other regions and in another context.

From a scientific perspective **the relevance of local mutual dependencies and understanding their implications for impacts on socio-economic dimensions**, such as generating winners and losers from circular transitions is highly relevant. **Once, new policy measures are implemented, effects might be felt in distant regions that were not involved in the decision making**. Understanding these impacts at a 'beyond national level' is an attractive future pathway. Further extension connection for circular transitions, such as conducted in RESOURCE depicting the impacts on Madrid by circular boosts in Aragon and vice versa are promising roads to take. Potentially the exact details will be refined, once better data is available.

## 4 Conclusions and next steps

The region of Aragon and other regions striving for circular transitions should well understand their position within global knowledge networks and potentially improve these. The accessibility to specific knowledge is crucial and a key leverage for a successful transition and

successful innovation activities. The analyses presented in D5.6 highlight that Aragon's circular transition and innovation depend on the structure and connectivity of its innovation and capability networks as much as on individual technology. The results provide actionable insights and strategies for regional policymakers, intermediaries support and firms seeking to strengthen circular economic synergies.

#### **a) Strengthen regional circular innovation ecosystems**

A resilient circular economy in Aragon depends on the strength of its regional innovation ecosystem, that is, the diversity and connectivity of actors involved in generating, applying and connecting to new knowledge items. Our analyses show that regions where firms, public institutions, and intermediary organisations collaborate through dense networks achieve higher levels of circular innovation and diffusion.

Regional policymakers should therefore focus on anchoring key knowledge actors and facilitating structured collaboration across sectors. For instance, attracting KIBS and research organizations as regional anchors can enhance innovation brokerage and knowledge transfer. Complementary measures include establishing circular innovation hubs, university–industry partnership schemes, and cluster-based projects that promote cross-sector experimentation.

To sustain long-term collaboration, governance structures such as multi-actor working groups or regional innovation councils can ensure continuity between project-based cooperation and ongoing policy learning. Aligning funding instruments, such as R&D vouchers, innovation grants, local knowledge exchange events, and regional smart-specialisation initiatives, with circular economy priorities will help mobilise both private and public actors around shared goals.

In the case of Aragon, it might be promising to explicitly strengthen ties between the three subregions, such that Teruel and Huesca benefit from the advantageous connection and relations that Zaragoza reveals to have.

#### **b) Enhance interregional and organizational connectivity**

The results demonstrate that circular innovation is shaped not only by local assets but also by the connections linking Aragon to external knowledge, actors and production networks. Organisational proximity, through shared ownership structures, supply-chain linkages, and collaborative projects, plays a key role in facilitating the diffusion of circular practices across regions.

Regional policies should therefore focus on improving both spatial and organisational connectivity, creating mutual reinforcements. Strengthening partnerships with neighbouring regions, research centres, and industrial clusters can create two-way channels for knowledge exchange and improves the likelihood to early benefit from new (global) developments. Programmes supporting joint demonstration projects, interregional alliances, and professional mobility schemes can help transfer expertise and best practices from more advanced hubs while allowing Aragon to showcase its own innovations.

Supporting the creation of branch offices, spin-offs, or project subsidiaries of major knowledge-intensive business service and manufacturing firms in Aragon can also localise global knowledge flows. Such initiatives enable smaller or peripheral regions to benefit from the organisational pipelines of larger firms without requiring headquarters relocations.

Moreover, investing in digital and transport infrastructure and fostering interoperability between regional data and monitoring systems can further reduce communication costs and barriers between innovation actors. These measures would allow circular innovations to diffuse more rapidly and inclusively across regions.

### **c) Use analytical evidence for strategic planning**

The analytical frameworks developed within RESOURCE and presented in D5.6 offer valuable tools for supporting evidence-based decision-making in regional circular economy policy. These approaches make it possible to trace how innovation, investment, and environmental impacts propagate through both spatial and organisational networks.

Regional policymakers can use such tools to identify high-impact sectors, prioritise circular economy investments, and anticipate potential trade-off between economy and environmental goals. For instance, simulation results can highlight which industries generate the strongest local multiplier effects, or which supply-chain linkages are most critical for achieving decarbonisation and material efficiency targets. Integrating these analytical tools into policy planning and evaluation processes would enhance the region's ability to design adaptive and coherent strategies.

### **d) Move beyond technological invention and build regional circular commercialization and adaptation capacity**

The findings highlight that successful regional circular transitions do not only depend on technological invention, but also on the capacity to commercialise and scale circular innovations. Many regions possess strong research and industrial capabilities but face barriers when translating technical solutions into viable market offerings. Strengthening this commercialisation capacity is therefore essential for generating sustained economic and environmental impact.

Regional and national governments can play a pivotal important role by creating early demand for circular products and services through strategic procurement, such as mobility-as-a-service or electronics-as-a-service schemes. They can also de-risk private investment in new business models through guarantees and milestone-based grants. Parallel support for branding and trademark development can help firms build trusted market identities and reduce perceived user risks. By combining technological innovation with market and social innovation, Aragon could expand the reach and resilience of its circular economy, turning invention into adoption and systemic regional impact.

As there is an indication for strong connections with other Spanish regions, such as Madrid, establishing cross-regional related strategies and offices can be a significant plus.

**e) Keep an eye on other unexpected spillover effects**

Whenever a transition takes place or is triggered through political or economic processes and adjustments there will be side-effects to economically connected regions. Our research revealed spillovers to Madrid and Barcelona. Understanding who is impacted, how other regions and players are facing pressures and identifying the channels will help overcoming frictions. Coping with unintended outcomes provides a relevant dimension to ensure inclusive and fair circular transitions.

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