Aalto University

POLICY BRIEF
19 February 2024

Accelerating circular economy through informational infrastructures

Niko Lipiäinen & Robin Gustafsson

Abstract

Despite the circular economy's rising prominence in academic, business, and political realms, challenges persist due to regulatory hurdles, data sharing concerns, and resource limitations among businesses. This policy brief identifies three challenges and offers detailed recommendations for overcoming them. It emphasises the necessity for interoperable data platforms, the value of data reusability, and the importance of high-quality, impactful data to ensure efficient circular economy processes. Additionally, this policy brief addresses the need for viable platform and data-driven business models to reconcile supply and demand disparities, and suggests creating market incentives for sustainable resource use through informational infrastructures. Furthermore, the recommendations underscore the importance of digital collaboration platforms, and informational infrastructure-enabled market incentives and business models in driving systemic change toward sustainability. The insights and recommendations are derived from the IN2MISSION research project funded by Business Finland.

Challenges and recommendations

Challenges

Challenge 1. Regulatory and risk concerns in data sharing for circular economy innovation

Challenge 2. Characteristics of data hinder circular economy innovations

Challenge 3. Supply and demand do not meet without viable business models for circular economy platforms and data-based solutions

Policy recommendations

Recommendation 1. Make rules for data sharing and collaboration clear

Recommendation 2. Enhance data management for circular economy efficiency

Recommendation 3. Create incentives for circular economy market development by informational infrastructures

Keywords: IN2MISSION, circular economy, innovation policy, informational infrastructures
JEL: D80, L50, O38, Q01, Q55, Q56

Introduction

The circular economy has gained attention in academic literature (Corvellec et al., 2022; Geissdoerfer et al., 2017; Kirchherr et al., 2017; Korhonen et al., 2018, Riggs et al., 2024), business and politics (European Commission, 2020; EPA, 2022). However, coordination of policy work and actions is ineffective without collective situational awareness and knowledge (Håkonsson et al., 2022). Information infrastructures allow computers and humans to form useful knowledge of the external world enabling learning about the surrounding ecosystem and building shared situational awareness (Håkonsson et al., 2022; Zins, 2007). We define these informational infrastructures as a coordinating and enabling backbone where the exchange of information, intelligent coordination, and the pooling of data and digital tools can take place.

Efforts have already been made to build and utilise informational infrastructures, for example, Digital Product Passport (HaDEA, 2023) and material recycling platforms (Materiaalitori, 2024). However, these and other circular economy initiatives face challenges that well-functioning informational infrastructures may ease. Therefore, this policy brief aims to define the challenges and propose recommendations to accelerate the circular economy through informational infrastructures.

Material and methods

This policy brief is conducted as part of the Informational Infrastructure to Accelerate Mission-Oriented System-Level Transformations (IN2MISSION) research project funded by Business Finland. In this research project, Aalto University and VTT Technical Research Centre of Finland seek to understand the most impactful innovation policy tools that will accelerate the development of solutions to grand challenges (IN2MISSION, 2024). The challenges and recommendations presented in this policy brief are based on a synthesis of a review of the state of circular economy in the European Union and Finland and the workshop held on 27 September 2023 with leading experts in circular economy and digital solutions related to it.

Results

Challenge 1: Regulatory and risk concerns in data sharing for circular economy innovation

- **Regulatory hurdles in data collaboration.** One of the critical barriers to fostering circular economy innovations, particularly in the retail sector, stems from competition laws. These laws inadvertently impede the pooling of data among competing businesses due to concerns over potential cartel formations. This regulatory environment creates a situation where sharing business-related data, including supply chain information, efficiency metrics, and material disclosures, becomes a legal minefield. These data types are often intertwined with critical economic factors, making it challenging to separate them from competitive intelligence. Additionally, uncertainties surrounding material reuse management and transportation permits further exacerbate the risk, as the liability for waste remains with the company until all legal documentation is appropriately transferred.

- **Fears related to data sharing.** Companies often grapple with the complexities of data sharing. Concerns range from the logistical aspects, such as how and where to share data, to managing shared data platforms. The expectation that data management should fall to a third party or a public entity further complicates the situation. No single producer or public body can realistically oversee data across an entire value chain or product lifecycle. These uncertainties fuel a reluctance to engage in data sharing, driven by a lack of understanding and fear of breaching competition laws. This hesitation is compounded by concerns over giving competitors access to sensitive information like product margins.

- **Resource limitations.** Despite a growing inclination towards embracing circular economy practices and collaboration, many companies, especially small and medium-sized enterprises (SMEs), find themselves constrained by resource limitations. The transition to circular economy models often requires significant investment in development and pilot projects, which is a prohibitive factor for many businesses. Furthermore, current financial instruments' complexity and bureaucratic nature for collaborative projects can be daunting, particularly for SMEs. This situation is exacerbated when larger companies, with more resources, dictate the direction of these initiatives, leaving smaller entities struggling to keep pace. Moreover, effectively tracking and managing the resource streams that products and services depend on is challenging regarding resource use and the value it brings to companies, particularly those with limited resources.

Recommendation 1: **Make rules for data sharing and collaboration clear**

- **Rules for permissible data sharing within competition law.** Amend competition laws to specify the types of data that can be shared without violating these laws. This specification should clearly distinguish between data that promotes environmental initiatives and data that could be used for anti-competitive practices.
- **Information about the financial benefits of data sharing.** Circular economy actors need to develop frameworks to articulate and demonstrate the financial advantages of data sharing. These frameworks should include case studies and models showing how shared environmental data can lead to cost savings, efficiency improvements, and new revenue streams.
- **Interoperable data platforms for the circular economy.** Advocate for the development of data platforms capable of connecting diverse systems. These platforms should allow seamless integration at various interfaces, ensuring compatibility across different technological solutions. This approach will enable a more cohesive ecosystem where data can be shared efficiently and securely.
- **Financial support for collaborative data-sharing ecosystems.** Introduce and promote financial instruments specifically designed to support joint ventures in development, piloting, and innovation within circular economy ecosystems. These instruments should be accessible and tailored to meet the needs of various stakeholders, including SMEs, to encourage widespread participation in circular economy initiatives.

Challenge 2: **Characteristics of data hinder circular economy innovations**

- **Data quality and its impact on utilisation.** The quality of data significantly influences the effectiveness of circular economy practices. A common issue is the lack of detailed coding in used material categorisation. For instance, in the case of iron reuse, knowing the precise quantity, composition, and strength is crucial for its effective reuse. Similarly, the absence of comprehensive data on construction products and their conditions impedes the reuse of materials during building demolitions. This challenge is commonly exacerbated by minor oversights, such as incorrect materials' coding, which can have far-reaching implications on the recycling and reuse processes.

- **Data reliability and validation concerns.** The reliability of environmental data, such as pre-calculated carbon footprints, often comes into question due to the unavailability of underlying raw data like energy consumption or production volumes. This issue is particularly pronounced when the data is not externally validated, leading to scepticism about its accuracy. The variability in data sources, ranging from manually inputted spreadsheets to automated enterprise resource planning systems, further complicates the reliability issue.

- **Data temporality challenges.** Data temporality plays a critical role, especially when the data is used for decision support in the circular economy context. For instance, planning the reuse of demolition materials or soil masses requires timely information about their location and quality. The temporal aspect becomes crucial in scenarios like demolitions planned for the future, where advanced planning is necessary for efficient material utilisation. Additionally, the identity and characteristics of materials and products evolve, such as when construction materials become recycled raw materials. The responsibility for updating these changing identities, essential for lifecycle and carbon footprint calculations, often remains unclear. Many companies, especially in sectors like electronic waste recycling, are reluctant to invest extra effort in continually tracking and updating this information.

- **Sustainability of data management.** Another critical aspect is the environmental impact of the data itself. Data production, transfer, combination, and storage necessitate significant amounts of energy, plastics, rare metals, and other natural resources, contributing to a considerable carbon footprint. This impact is expected to escalate with the expanding information and communications technology industry and the increasing use of advanced technologies like artificial intelligence (AI). The challenge lies in balancing the benefits of data utilisation with the sustainability of the data management processes.

Recommendation 2: **Enhance data management for circular economy efficiency**

To truly harness the potential of data in advancing the circular economy, a multi-faceted approach focusing on clarity, sustainability, value generation, and seamless integration is essential.

- **Clarified circular economy objectives and data roles.** It is crucial to clearly define the primary goals of the circular economy that data can support. This involves identifying specific use cases, relevant stakeholders, business drivers, and regulatory constraints. Highlighting successful examples where data usage has led to significant environmental impact reductions, with quantifiable monetary benefits, is critical to motivate and guide the development of best practices.
- **Promote data reusability.** Given the substantial carbon footprint associated with data production, it is important to consider ways in which data reusability can be established. This approach would enhance the sustainability of data management and maximise the return on environmental and economic investments in data collection and processing.
- **Focus on impactful data.** Determine the data types that hold the most value in the context of circular economy initiatives. This involves pinpointing the minimum yet impactful dataset necessary to drive meaningful change. This targeted approach ensures that data collection is efficient and relevant, and directly contributes to achieving circular economy objectives.
- **Seamless data flow across value chains.** The cost and complexity of data integration should not be prohibitive, especially for smaller players. Data should flow effortlessly within the value chain, minimising the need for manual entry and system-to-system transfers. Developing interfaces that communicate effectively with each other is key, and this should be made financially accessible to small and medium-sized enterprises.
- **Priority on data quality.** Emphasise the importance of high-quality data at the initial stages of the lifecycle. The quality of data at the outset has a multiplying effect throughout the cycle, impacting the effectiveness and efficiency of circular economy processes. Ensuring data accuracy and completeness from the beginning is fundamental to the success of circular economy initiatives.

Challenge 3: Supply and demand do not meet without viable business models for circular economy platforms and data-based solutions

- **Critical mass for circular economy platforms.** Achieving a critical mass of participants is essential for the success of circular economy platforms, as viable business models are contingent on a balanced presence of both demand and supply. However, this equilibrium is often disrupted by challenges such as the labour-intensive nature of data handling and a sustainability paradox where the demand side's need for used materials contradicts the supply side's goal of waste reduction. Additionally, even though there is a clear need for recycled materials, companies frequently face barriers in accessing these material flows. This issue is particularly pronounced at the end of product lifecycles, notably in the construction industry. The existence of multiple marketplaces in different industries and regions further complicates this, as it disperses the user base, preventing the accumulation of critical mass for these platforms to thrive.

- **Uncertainties and risks in material reuse lead to unbalanced demand and supply.** The circular economy is significantly affected by uncertainties and risks in material reuse, which create imbalances between demand and supply. While striving to reduce waste, companies face the issue of material reuse volume fluctuation, which complicates the market dynamics for those using reused materials. They require a consistent volume and assurance about the availability of reused materials. Additionally, there is a reluctance to participate in recycling platforms due to concerns over appropriate material reuse treatment and the associated reputational risks.

- **Disparities in data management and market participation in material reuse.** The challenge of disparities in data management and market participation particularly affects smaller companies in the circular economy. These companies, primarily focused on their core business operations, often find it difficult to allocate resources and time towards participating in the used material market. The task of manually entering data into trading platforms is not only labour-intensive but also requires a level of expertise and resources that many smaller entities lack. For example, small companies do not have resources or knowledge for data production or management, even less for calculating carbon footprint from this data. Further, the development level of data management varies between countries, even in the EU, which puts additional requirements on adapting data management for companies. Consequently, there's a risk that only large-scale actors are equipped to meet the demands of data collection and reporting, creating an uneven playing field in the used material market.

- **Missing market incentives for sustainable resource use.** The challenge in creating market incentives for sustainable resource use lies in effectively steering business and market practices towards environmentally beneficial actions that also offer customer value. A primary issue is the misleading nature of reused material transaction values. For example, the cost of transporting crushed concrete often outweighs its market value, deterring recycling efforts. However, the environmental cost of producing new concrete – in terms of a higher carbon footprint – justifies transporting recycled concrete over longer distances, despite its lower transaction value.

  Current environmental strategies focus heavily on recycling at the end of a product's lifecycle. However, there is significant potential for extending lifecycles, particularly in durable goods such as heavy machinery. In the consumer sector, characterised by a preference for variety and change, as seen in textiles and electronics, the sharing economy

model may not be the most eco-efficient approach. For instance, shared clothing might require more transportation, chemical treatments, and repairs compared to long-term ownership of the same item.

Moreover, supply chains are marked by their length and complexity, especially in sectors like the food industry, which leads to substantial natural resource consumption in transportation. Inefficiencies are also present in waste management systems, such as in Finnish household waste collection where garbage trucks are only sometimes optimally utilised. While technological advancements could enhance these processes, the high costs of such investments are a significant obstacle to their implementation.

Recommendation 3: **Create incentives for circular economy market development by informational infrastructures**

We make three recommendations for incentives for market creation by informational infrastructures. These three approaches should be fostered jointly as they are coupled with each other.

- **Informational infrastructures as market instruments for circular economy.** Informational infrastructures can act as market instruments for enabling a circular economy. Furthermore, these information infrastructures are needed for linking supply and demand, while ensuring timely and efficient resource circulation. Hence, there is a need for a kind of 'metro thinking', where each step in the life cycle phase corresponds to a station where demand and supply meet while simultaneously incorporating in each step the intended destination. Constructing a series of interconnected 'stations' is essential, linking various stakeholders in the process. The solutions implemented should align with market economy principles, ensuring consumers have access to diverse options through ownership or borrowing while using fewer resources. Legal sandbox-type experimental environments can support these kinds of efforts.

  Market progress can be facilitated through certifications that utilise informational infrastructures. This involves defining material and data standards for end-of-lifecycle materials that transition from waste to product, such as crushed concrete and recycled plastic. For example, certified third-party validation for data creates a market for consultancy services. To establish effective circular economy markets, it becomes imperative to extend similar regulations to operators beyond the EU borders, or at the very least, within the EU itself.

  Information infrastructures can support establishing a market for carbon recovery, which involves generating revenue through the preservation of natural resources, such as forests. Markets can be directed to incorporate the genuine value of raw materials by considering factors like carbon footprint, biodiversity, and erosion. For instance, concrete production involves sand excavation, leading to erosion and biodiversity effects. Platforms and data mediators can support calculating and sharing indicators for these effects beyond monetary considerations. Introducing an annual carbon budget for individuals or companies, akin to gamification, encourages sustainable practices. Therefore, indicators for sustainable growth should encompass improved circularity and responsible use of natural resources.

  Smaller companies encounter challenges independently establishing a viable market, especially in the circular economy where substantial volumes are essential. Guiding market development would be beneficial for them. One approach to steer market creation involves

mandating data production, achievable through straightforward methods like quick-response (QR) code identification. Optimisation of household garbage collection is possible with technologies such as radio frequency identification (RFID) and AI. For instance, the UK mandates the weighing of imported masses for recycling.

- **Digital collaborative platforms for the circular economy.** The aim should be to reduce physical movement and work by increasing data movement and digitalisation. Nevertheless, constructing comprehensive value chain platforms surpasses the capabilities of individual companies. For instance, consider the challenge of tracking containers globally within the logistics sector.

  End-of-life recycling platforms must be more collaboration-focused than trade-focused, due to uncertainties of raw material contents, amounts, and availability. Efficient and reliable recording of material life cycles could alleviate these uncertainties. Collaboration platforms serve as meeting grounds where stakeholders can openly discuss and share the latest information. This convergence of diverse parties facilitates mutual understanding beyond mere assembly to actively support activities, disseminate up-to-date information, and provide training. However, it's important to note that platforms can't be used to share information restricted by nondisclosure agreements.

  For experimental platform pilots, emphasis should be placed on industries or material flows where the greatest impact can be achievable. These pilots should yield tangible benefits applicable to various stakeholders and align with specific data-driven objectives.

- **New informational infrastructure enabled business models for the circular economy.** Businesses should be steered away from traditional linear approaches to ones emphasising lifecycle extension and sustainability. The aim is to prolong the lifespan of products through strategies such as redesign and offering services like free repairs, akin to practices employed by companies like Patagonia. This approach promotes a shift in business models from being purely volume-centric to also valuing product quality. Platform solutions could be instrumental in diminishing the prevailing culture of consumption, for example, fast fashion. Utilising data effectively can foster a deeper understanding of product quality, whether it pertains to garments, household appliances, or other products, thereby enhancing consumer confidence and willingness to pay a premium for higher quality and sustainable products.

  Furthermore, service-based business models that emphasise sustainability are promising ways to emphasise lifecycle extension and sustainability. The development of supporting informational infrastructures that enable service-based business models should therefore be encouraged. These infrastructures could be designed to manage and analyse data transparently, guiding customers towards renting or paying annually for high-quality, efficient products that result in fewer emissions.

  Finally, information infrastructure-enabled business models for the circular economy should be encouraged by demonstrating the value of reusing and enhancing existing assets. For example, adding advanced technology to older machinery prolongs their lifespan. Additionally, informational infrastructures for promoting investment in human labour can further support this transition.

Contact

Professor Robin Gustafsson
Aalto University, Department of Industrial Engineering and Management
P.O.Box 15500, FI-00076 Aalto
Tel. +358 50 316 0981
robin.gustafsson@aalto.fi
@robingustafs #platformeconomy #IN2MISSION

Researcher Niko Lipiäinen
Aalto University, Department of Industrial Engineering and Management
P.O.Box 15500, FI-00076 Aalto
Tel. +358 503312189
niko.lipiainen@aalto.fi
@NLipiain #platformeconomy #IN2MISSION

References

Corvellec, H., Stowell, A. F., & Johansson, N. (2022). Critiques of the circular economy. Journal of industrial ecology, 26(2), 421-432.

European Commission. (2020). Communication from the commission to the European parliament, the council, the European Economic and Social Committee and the committee of the regions - A new Circular Economy Action Plan for a Cleaner and More Competitive Europe. Available at https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=COM:2020:98:FIN

EPA. (2022). Building A Circular Economy For All: Progress Toward Transformative Change. United States Environmental Protection Agency. Available at https://www.epa.gov/system/files/documents/2022-09/EPA_Circular_Economy_Progress_Report_Sept_2022.pdf

Geissdoerfer, M., Savaget, P., Bocken, N. M., & Hultink, E. J. (2017). The Circular Economy–A new sustainability paradigm?. Journal of cleaner production, 143, 757-768.

HaDEA. (2023). Digital Product Passport - call for proposals. European Health and Digital Executive Agency. Available at https://hadea.ec.europa.eu/calls-proposals/digital-product-passport_en

Håkonsson, D. D., Larsen, E. R., & Eskildsen, J. K. (2022). Effective Information Infrastructures for Collaborative Organizing: The Case of Maasai Mara. Organization Science. https://doi.org/10.1287/orsc.2022.1642

IN2MISSION. (2024). The Informational Infrastructure to Accelerate Mission-Oriented System-Level Transformations. https://www.aalto.fi/en/IN2MISSION

Kirchherr, J., Reike, D., & Hekkert, M. (2017). Conceptualizing the circular economy: An analysis of 114 definitions. Resources, conservation and recycling, 127, 221-232.

Korhonen, J., Honkasalo, A., & Seppälä, J. (2018). Circular economy: the concept and its limitations. Ecological economics, 143, 37-46.

Materiaalitori. (2024). Circular economy marketplace for businesses. Available at https://materiaalitori.fi

Riggs, R., Felipe, C., Roldán, J., & Real, J. (2024). Information systems capabilities value creation through circular economy practices in uncertain environments A conditional mediation model, Journal of Business Research. https://doi.org/10.1016/j.jbusres.2024.114526

Zins, C. (2007). Conceptual approaches for defining data, information, and knowledge. Journal of the American Society for Information Science and Technology, 58(4), 479–493. https://doi.org/10.1002/asi.20508