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Circular Economy Practices and Barriers within European SMEs in the Construction Sector

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ABSTRACT:
Despite growing policy ambition under the European Green Deal and Circular Economy Action Plan, circular economy (CE) adoption among resource-intensive sectors, such as the construction sector, remains limited. This study provides the first large-scale quantitative assessment of the difficulties experienced within the European SMEs in the construction sector during transitioning to environmentally sustainable CE implementation. Analyzing data from 2,242 SMEs in the 2024 Flash Eurobarometer 549 survey, the study used logistic regression to test four hypotheses on cost, administrative, expertise, and market-related barriers across nine CE practices. The findings reveal that while operational CE actions, such as resource efficiency in water, energy, and materials, are relatively widespread, more systemic strategies like circular design and switching to greener suppliers of materials are underutilized. Not surprisingly, cost is the most commonly reported difficulty by SMEs in the construction sector. Technical, administrative and market-related difficulties are not often considered significant barriers. Challenges linked to environmental reporting arise in a couple of models, indicating a moderate concern rather than a widespread barrier. Finally, firm size tends to boost the likelihood of undertaking CE actions, pointing to the importance of organizational resources, whereas turnover and company age show no significant results. These results emphasize the need for targeted policy measures that build internal capabilities, stimulate market demand, and accelerate more advanced CE transitions within the construction sector.

Keywords: Circular Economy (CE) adoption, Construction SMEs, Sustainability Barriers, Resource Efficiency, Flash Eurobarometer

1. Introduction

The circular economy (CE) is conceptualized as a closed-loop system that mimics natural processes, fundamentally contrasting the linear "take-make-waste" economic model (Triguero et al., 2022). Unlike linear systems that lead from cradle to grave, CE adopts a cradle-to-cradle perspective. Traditional product lifecycles, comprising raw material extraction, production, transportation, and disposal, emphasize end-of-life recycling (Antwi-Afari et al., 2022; Katz - Gerro & López Sintas, 2019). However, CE advocates for intervention earlier in the cycle by prioritizing resource efficiency, reuse of post-consumer materials, and sustainable product design (Dey et al., 2022).

The construction sector represents one of the most resource-intensive and environmentally impactful industries globally. It consumes a significant amount of the world's raw materials and is responsible for generating a large proportion of landfill waste, estimated to be between 35% and 65% (HaitherAli & Anjali, 2024; Sáez-de-Guinoa et al., 2022). This sector also accounts for a substantial percentage of global energy consumption

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and greenhouse gas emissions. Construction and demolition waste (CDW) constitutes a major waste stream in urbanized regions (Kabirifar et al., 2020; Zhang et al., 2022). Given this significant environmental footprint, transitioning to a circular production and consumption system is considered crucial for the sector.

The European Union is applying growing regulatory pressure to speed up the transition to a circular economy. Under the umbrella of the European Green Deal, Europa has integrated CE principles to support sustainable production and consumption (Commission, 2022). With the Circular Economy Action Plan (CEAP), launched in 2020, Europe promotes sustainable product design, waste prevention, and regenerative economic models to decouple growth from resource use (Kuci & Fogarassy, 2021) and foster transitioning the EU economy from a linear model of production and consumption to a circular one (EU, 2020; Spani, 2020). CEAP outlines a comprehensive strategy to minimize waste generation, extend the lifecycle of products, and promote regenerative economic practices across multiple sectors (Jenet et al., 2024) .

However, despite these regulatory efforts, actual implementation among businesses remains limited (European Environment Agency, 2024). The EU's material footprint and circularity rates have stagnated, with resource accumulation in material stocks growing by 2.6% annually. While nearly half of generated waste is recycled, systemic change remains slow, particularly in high-impact sectors, such as construction (European Environment Agency, 2024). Significant barriers impede CE implementation, particularly among small and medium-sized enterprises (SMEs), which constitute 99% of EU businesses and about 95% of firms in the construction sector (Commission, n.d; John et al., 2023; Zuofa et al., 2023). SMEs face unique challenges, including limited financial resources, fragmented operations, and lack of technical knowledge (Dey et al., 2022). The high-risk and capital-intensive nature of construction further complicates CE adoption among SMEs (Atta, 2023; Ghufran et al., 2022; Gomes & Pinho, 2023; Guldmann & Huulgaard, 2020; Sayed Mohammad Ayati, 2022). These constraints hinder the practical application of CE policies and diminish the effectiveness of EU directives (Gasparri et al., 2023).

While literature reviews have already explored CE barriers and enablers, empirical evidence remains scarce, particularly for the construction sector. Existing research often focuses on theoretical frameworks or qualitative case studies through stakeholders' interviews (see for example (Mura et al., 2020) and (Sharma et al., 2021)), these approaches are often limited in scope and lack generalizability across the sector. Previous literature reviews (see e.g., (Munaro & Tavares, 2023; Sajid et al., 2024)) have specifically focused on construction, as the barriers are typical and often unique to this sector, distinguishing it from other industries. While some general barriers to CE adoption exist across various sectors, they are often amplified or take on specific forms within the construction industry due to its inherent characteristics. More specifically, the excessively fragmented supply chain networks involving many stakeholders with varying interests, together with long product lifecycles, impede the transition to CE by limiting opportunities for quick material recovery and reuse (Ababio & Lu, 2023; AlJaber, 2023; Durdyev et al., 2023; Munaro & Tavares, 2023). Additionally, the construction sector is widely described as having an "industry conservatism" which represents a significant cultural barrier (Munaro & Tavares, 2023). Consequently, these sector-specific constraints may render findings inapplicable to other industries, reinforcing the need for a sector-specific analyses. This study aims to address this gap through a large-scale quantitative analysis. Utilizing data from the 2024 edition of the Flash Eurobarometer 549 (European Commission, 2025), the research investigates the extent of CE adoption and identifies the difficulties in implementing CE activities across construction SMEs in Europe. Therefore, the main research questions for this paper are:

1. To what extent have SMEs in the construction sector adopted circular economy (CE) practices?
2. What were the main barriers experienced during implementation of these practices?

This study provides the first large-scale quantitative assessment of circular economy (CE) practices among 2,242 construction SMEs across the EU27. The findings of the study reveal widespread adoption of basic resource-efficiency actions, while systemic CE measures remain limited. Cost is the most commonly reported barrier among CE adopters. Administrative and expertise-related difficulties vary by action and are often linked to regulatory complexity. Results highlight the need for targeted policy to address cost pressures, streamline compliance, and support technically demanding CE transitions.

2. Literature Review

2.1 The construction sector and circular economy

The construction industry is a cornerstone of economic growth and urbanization but also one of the most environmentally damaging sectors. It accounts for 40% of global material extraction and 39% of total CO_2 emissions, with 11% linked to material production (Charef et al., 2021; Dsilva et al., 2023; Hoosain et al., 2021). Its reliance on linear "take-make-dispose" processes exacerbates inefficiencies and waste, particularly as construction and demolition (C&D) waste presents nearly one-third of global solid waste (Shooshtarian et al., 2022).

Due to climate change and resource scarcity concerns, the sector is increasingly targeted for circular economy (CE) interventions aimed at enhancing resource efficiency (Guerra et al., 2021). A paradigm shift toward a "take-make-design" approach offers potential to mitigate environmental impacts (HaitherAli & Anjali, 2024). Successful CE implementation requires understanding the construction supply chain, stakeholder roles, and lifecycle of materials (Guerra et al., 2021). Research has increasingly emphasized sustainable innovations, including recycled aggregates, bio-based materials, and low-carbon cement alternatives (Banihashemi et al., 2023; Dsilva et al., 2023; Sizirici et al., 2021; Tupenaite et al., 2023).

Effective C&D waste management is vital. Strategies such as on-site sorting, deconstruction, and design-for-disassembly facilitate reuse (Loizou et al., 2021; Quéheille et al., 2022), while digital technologies optimize waste tracking and reuse decisions (Farjana et al., 2023). Cement production alone contributes 8% of global CO_2 emissions (Guo et al., 2021)), and construction runoff continues to damage ecosystems (Jiayin et al., 2020). In response, sustainable practices like energy-efficient design, green infrastructure, and renewable integration offer mitigation pathways (Reddy et al., 2024).

Researchers also advocate CE oriented design principles like adaptability, durability, and recyclability to extend building lifespans and minimize resource input to support a systemic shift toward sustainable, circular construction (Atta, 2023; Bertino et al., 2021; Hoosain et al., 2021; Quéheille et al., 2022; Umoh et al., 2024).

Despite this potential, researchers have found several barriers hinder CE adoption (Kalar, 2021). High upfront costs, insufficient R&D, and uncertain returns deter adoption, particularly among SMEs (Försterling et al., 2023; Kalar, 2021; Saarinen & Aarikka-Stenroos, 2023; Shooshtarian et al., 2022; Takacs et al., 2022). Moreover, skill gaps, weak policy enforcement, and limited public awareness continue to obstruct systemic uptake (Charef et al., 2021). In addition, market failures, supply and demand mismatch, compound the issue (Osei-Tutu et al., 2023). Weak institutional coordination and low public awareness also undermine systemic adoption (Ababio & Lu, 2023; Durdyev et al., 2023). Bassi and Dias (2019) argued that due to limited capacity and resources, most SMEs focus on basic incremental improvements (resource efficiency and waste reduction) while comparatively few undertake deeper circular innovations like product redesign. Recent researches across regions also reinforce that SMEs put greater emphasis on basic resource-saving CE measures, such as saving energy, water, materials, and minimizing waste, over systemic CE practices like product redesign, renewable energy integration, and circular business models that would fundamentally transform their business models toward a circular economy (Barreiro - Gen & Lozano, 2020; Levický et al., 2022). This paper therefore addresses the first research objective: "To what extent have SMEs in the construction sector adopted circular economy (CE) practices?"

2.2 Circular Economy by SMEs in the Construction Sector

The construction sector heavily depends on SMEs, which play key roles across supply, design, and waste management (Dey et al., 2022; Zuofa et al., 2023). This synergy supports innovation and sustainability (Atta, 2023), yet SMEs face significant barriers to circular economy adoption including financial, technical, and regulatory challenges-hindering broader sectoral transformation (Atta, 2023; Dey et al., 2022; Zuofa et al., 2023).

2.2.1 Financial Barriers

High upfront costs remain the most critical financial barrier to CE adoption among construction SMEs, requiring investments beyond their capacity in technologies and designs (Ababio & Lu, 2023). Limited access to affordable financing further compounds this issue, as financial institutions frequently view CE initiatives as high-risk due to uncertain returns and untested models (Saarinen & Aarikka-Stenroos, 2023). Consequently, SMEs often face restrictive lending conditions, excluding them from the necessary credit. Internal cash flow limitations and insufficient governmental incentives also undermine SMEs' ability to justify initial CE investments, which include not only technologies but also workforce training and process restructuring (Karaca et al., 2024). Consistent public support is therefore essential to alleviate these costs and stimulate SME engagement (Bucea-Manea-Ţoniş et al., 2021; Melati et al., 2021). Additionally, the fragmented structure of the construction sector and immature markets for reused materials intensify financial risks (Cruz Rios et al., 2021; Munaro & Tavares, 2023). Accordingly, this paper's second research objective addresses the hypothesis:

H1: SMEs in the construction sector that have implemented at least one circular-economy (CE) measure, perceiving the cost of environmental actions as a difficulty is significantly associated with the likelihood of implementing each specific CE action.

2.2.2 Regulatory Complexity

Regulatory complexity has consistently been identified as a significant barrier to the adoption of CE practices in the construction sector. AlJaber (2023), for instance, highlight that the construction industry is governed by a vast array of regulations, standards, and norms that vary considerably across jurisdictions and governing authorities. In recent years, the European Union has actively sought to address this complexity through new regulatory initiatives aimed specifically at promoting CE adoption. One of the key efforts in this regard is the revised Circular Economy Action Plan (2020), which outlines concrete measures to accelerate the transition to a circular economy across member states (EU, 2020; Spani, 2020). Complementary regulations, such as the EU Waste Framework Directive and initiatives like the EU Taxonomy Regulation and the Corporate Sustainability Reporting Directive (CSRD), further aim to embed CE principles into corporate reporting and investment decision-making (Backes, 2020; de Gier, 2022; EU, 2022). Although the CSRD currently targets larger enterprises, its ripple effects are expected to extend across entire supply chains, impacting SMEs indirectly. Moreover, several Member States have launched national projects and policy instruments to support CE implementation. However, significant differences persist between countries in how these initiatives are framed and enforced. Some studies (Giorgi et al., 2022) have found that CE strategies remain fragmented and unevenly promoted across the EU, with varying degrees of institutional commitment. This regulatory heterogeneity can lead to confusion, delays, and even contradictions, especially for SMEs operating across borders. SMEs, lacking legal expertise and resources, navigating this complex patchwork of national and EU regulations, are especially vulnerable to the burdens imposed by disjointed certification, labelling, and reporting requirements (Giorgi et al., 2022; Hancook, 2024; Moneva et al., 2023; Osei-Tutu et al., 2023; Takacs et al., 2022). Despite growing policy momentum, little empirical research exists on how specific rules and procedures are experienced by SMEs as burdensome or obstructive. Although earlier literature reviews (e.g., (Charef et al., 2021; Wuni, 2022)) identified such sector-specific regulatory risks, empirical validation remains limited. These insights affirm the study's second research objective and hypothesis:

H2: SMEs in the construction sector that have implemented at least one circular-economy (CE) measure, perceiving administrative or technical procedural complexity is significantly associated with the likelihood of implementing each specific CE action.

2.2.3 Technological Limitations, Innovation Barriers, Skill Manpower and Knowledge Gaps

Another critical challenge to circular economy (CE) adoption among SMEs in the construction sector is the lack of technical expertise and specialized skills. Numerous studies highlight that insufficient knowledge of CE integration and limited access to skilled professionals hinder innovation and implementation (Ababio & Lu, 2023; Charef et al., 2021; Durdyev et al., 2023; García‐Quevedo et al., 2020; Gasparri et al., 2023; Guldmann & Huulgaard, 2020; Mishra et al., 2022; Osei-Tutu et al., 2023; Sáez-de-Guinoa et al., 2022; Zuofa et al., 2023). Mishra et al. (2022) emphasize that CE demands advanced technologies and operational innovation, yet many SMEs lack the internal capacity to apply them. Traditional training programs often overlook interdisciplinary CE competencies, leaving firms without qualified personnel (Ababio & Lu, 2023). Consequently, the hypothesis under the second research objective:

H3: SMEs in the construction sector that have implemented at least one circular-economy (CE) measure, perceiving a lack of environmental expertise as a difficulty is significantly associated with the likelihood of implementing each specific CE-action.

2.2.4 Market Challenges for Implementing Circularity Practices and Green Products in the Construction Sector

Substantial market-related barriers significantly hinder the adoption of CE practices among construction SMEs (Bassi, 2023; Durdyev et al., 2023; Osei-Tutu et al., 2023; Saarinen & Aarikka-Stenroos, 2023). While environmental awareness is increasing, cost considerations dominate purchasing decisions, with clients often perceiving green products as more expensive or lower in performance (Försterling et al., 2023; Saarinen & Aarikka-Stenroos, 2023). For SMEs operating with limited profit margins, weak consumer demand undermines the economic viability of CE investments (Antonioli et al., 2022). Concurrently, supply-side challenges, such as the limited availability, variable quality, and fluctuating prices of recycled materials, arise from underdeveloped markets and fragmented supply chains (AlJaber, 2023). These intertwined constraints reinforce one another: weak demand stifles sustainable supply development, while unstable supply deters broader CE uptake (AlJaber, 2023; Guerra & Leite, 2021). Thus, the following hypothesis is proposed under the second research objective:

H4: SMEs in the construction sector that have implemented at least one circular-economy (CE) measure, perceiving a lack of market demand is significantly associated with the likelihood of implementing each specific CE action.

3. Sample Selection and Research Design

3.1 Sample selection

This study utilizes data from the 2024 Flash Eurobarometer 549: SMEs, Resource Efficiency and Green Markets, hosted by the GESIS, Leibniz Institute for Social Sciences (European Commission, 2025). The survey spans 14 sectors across the EU-27, nine non-EU countries and the USA. Interviews targeted senior decision-makers (e.g., CEOs, financial or commercial managers) and were conducted via Computer-Assisted Telephone Interviewing (CATI), enhancing representativeness. However, the dataset is cross-sectional, limiting trends or causal analysis.

This research emphasizes a sector-specific approach. Following Arranz et al. (2024), the dataset was filtered to include only SMEs in the EU construction sector (NACE F) to ensure sectoral specificity and regulatory comparability across a single market. The sample includes micro, small, and medium-sized enterprises according to the European

SME size thresholds. The final sample comprises a comprehensive dataset of 2,242 construction SMEs within the EU-27.

3.2 Research Methodology

This study examines the descriptive analysis that identifies prevalent CE practices under research objective1, while regression models evaluate the barriers, the firms are facing during implementation of CE activities, under research objective2. The Flash Eurobarometer 549 survey asks firms what actions they are undertaking to be more resource efficient (Q1). There were nine response categories presented (European Commission, 2025):

1. "Saving water
2. Saving energy
3. Using predominantly renewable energy (e.g. including own production through solar panels, etc.)
4. Saving materials
5. Switching to greener suppliers of materials
6. Minimizing waste
7. Selling your residues and waste to another company
8. Recycling, by reusing material or waste within the company
9. Designing products that are easier to maintain, repair or reuse"

(European Commission, 2025)

Because each dependent variable is binary (namely implementing a certain CE action = 1 and 0 otherwise), we estimate nine separate binary-logistic regressions for each resource efficient CE activities on the subsample of firms that have implemented at least one CE action. The coefficients indicate whether reporting a given barrier is associated with a higher or lower probability of adopting a specific action. The model is specified as follows:

$$CEij = \alpha i + \beta i \ BARRIERij + \delta i \ CONTROLSij + €i$$

Firms that had taken at least one resource-efficiency action (Q1) were asked which difficulties they experienced while doing so (Q7). We recode the ten difficulties as binary dummies (1 = having difficulties; 0 = no difficulties) if the difficulty was ticked. The response categories as per Q7 were as follows (European Commission, 2025):

1. "Complexity of administrative or legal procedures.
2. Difficulty to adapt environmental legislation to your company
3. Technical requirements of the legislation not being up to date
4. Difficulty in choosing the right resource efficiency actions for your company
5. Cost of environmental actions
6. Lack of specific environmental expertise
7. Lack of supply of required materials, parts, products or services
8. Lack of demand for resource efficient products or services
9. Complexity associated with environmental labelling and certification
10. Complex environmental reporting requirements"

(European Commission, 2025)

Control variables were included to account for firm-level and country-level heterogeneity. These consist of the age (natural logarithm of firm age); size in terms of employees (natural logarithm of the number of employees) and the level of turnover , measured using a binary indicator of the turnover level where 1 represents companies with a turnover below or equal €2 million and 0 above. Country-fixed effects were captured through binary country dummies to control for policy and institutional variability.

Based on regression analysis, four hypotheses are tested, each corresponding to distinct dimensions of barriers: one cost-related dimension for Hypothesis 1; four administrative dimensions for Hypothesis 2; three expertise-related dimensions for Hypothesis 3; and two market-related dimensions for Hypothesis 4.

4. Results

4.1 Descriptive Statistics

According to the findings, nearly 93% of firms have engaged in at least one CE initiative aimed at improving resource efficiency. Based on the descriptive analysis, this study observes that minimizing waste (64,5%) and saving materials (60, 8%) and saving energy (58,6%) are the most prevalent resource-efficiency actions among construction SMEs. Circular economy adoption levels reveal a dichotomy between operational (e.g., resource efficiency) and systemic (e.g., circular redesign) strategies. Whereas roughly one-half to two-thirds of firms have already implemented operational measures, the share adopting systemic measures falls to about one-quarter to one-third.

Table 1: Adoption level of resource-efficiency CE actions

Resource-efficiency actions	**Firms (#)**	**Percentage (%)**
"Minimizing waste	1445	64,5
Saving materials	1363	60,8
Saving energy	1314	58,6
Recycling, by reusing material or waste within the company	1100	49,1
Saving water	1007	44,9
Switching to greener suppliers of materials	743	33,1
Designing products that are easier to maintain, repair or reuse	671	29,9
Selling your residues and waste to another company	659	29,4
Using predominantly renewable energy (e.g. including own production through solar panels, etc.)"	590	26,3

(European Commission, 2025)

Interestingly, firms implement about four actions on average. Nearly 60% of SMEs have adopted four actions, and around three-quarters remain below six actions.

Table 2: CE Activity Engagement across firms

No of CE Actions	Firms (#)	Percentage (%)	Cum. Percentage
0	157	7%	7%
1	210	9,4%	16,4%
2	251	11,2%	27,6%
3	327	14,6%	42,1%
4	365	16,3%	58,4%
5	326	14,5%	73%
6	274	12,2%	85,2%
7	196	8,7%	93,9%
8	107	4,8%	98,7%
9	29	1,3%	100%
Total	**2242**	**100%**	

SMEs implementing resource efficiency initiatives were surveyed about any challenges they faced during the setup process. The table below lists the difficulties in descending order of frequency.

Table 3: Reported difficulties in implementing resource-efficiency CE actions among firms

Difficulties when implementing resource-efficiency CE actions	Firms (#)	Percentage (%)
"Complexity of administrative or legal procedures.	730	32,6
Cost of environmental actions	637	28,4
Complex environmental reporting requirements	554	24,7
Difficulty to adapt environmental legislation to your company	515	23,0
Lack of supply of required materials, parts, products or services	496	22,1
Lack of specific environmental expertise	487	21,7
Complexity associated with environmental labelling and certification	466	20,8
Technical requirements of the legislation not being up to date	462	20,6
Difficulty in choosing the right resource efficiency actions for your company	451	20,1
Lack of demand for resource efficient products or services"	427	19,0

(European Commission, 2025)

Regulation-related difficulties, such as administrative complexity, adapting legislation, environmental reporting and technical requirements, are mentioned by roughly one-third to one-fifth of firms. This makes streamlining and clearer guidance a policy priority. In addition, 28% of companies perceive the cost of environmental actions as the second most common obstacle. By contrast, limited market demand is cited by only 19% of firms, which may be linked to the lower uptake of more systemic CE measures. Further descriptive statistics show that the firms in this study are mostly small firms. Although the average company has 54 employees, the median is only 12, showing that a few large firms pull the mean upward while the great majority are micro- or small enterprises. The firms in the sample are on average 22 years, with a median of 18 years, indicating a predominantly mature sample. In addition, nearly half of the companies report annual turnover below €500 000. Only a small minority (9 %) exceeds €10 million. Taken together, these indicators confirm that the sample dataset for this study is dominated by smaller construction SMEs. Finally, the country distribution is well balanced. Every EU Member State contributes between about 2% and 6% of observations, so no single nation dominates the analysis.

Table 4: Descriptive Statistics of Control Variables for Sample Firms

Control variables				
	N	**Mean**	**SD**	**Median**
Number of employees	2176	54,04	270,34	12
Age of the firm	1962	21,70	18,69	18

Annual turnover classification	**N**	**%**
€ 100,000 ≥ Turnover	440	19,7%
€ 100,000 < Turnover ≤ € 500,000	488	21,7%
€ 500,000 < Turnover ≤ € 2,000,000	461	20,6%
€ 2,000,000 < Turnover ≤ € 10,000,000	369	16,5%
€ 10,000,000 <Turnover	203	9,0%
	1961	

Country dummies

Country	**N**	**%**	**Country**	**N**	**%**	**Country**	**N**	**%**
Austria	91	4,1	France	96	4,3	Malta	40	1,8
Belgium	104	4,6	Germany	98	4,4	Netherlands	101	4,5
Bulgaria	73	3,3	Greece	68	3,0	Poland	87	3,9
Croatia	85	3,8	Hungary	70	3,1	Portugal	114	5,1
Cyprus	38	1,7	Ireland	72	3,2	Romania	127	5,7
Czech Republic	90	4,0	Italy	87	3,9	Slovakia	69	3,1
Denmark	85	3,8	Latvia	78	3,5	Slovenia	82	3,7
Estonia	98	4,4	Lithuania	78	3,5	Spain	96	4,3
Finland	79	3,5	Luxembourg	51	2,3	Sweden	80	3,6

4.2 Regression Results

This study estimates nine separate binary-logistic models, one for each circular-economy (CE) action. Each model includes the same control variables (firm age, size, and turnover), and each model accounts for cross-national differences via country fixed effects. The Nagelkerke R^2 is rather low across the models and ranges from 0.094 (Model 8: recycling) to 0.187 (Model 6: minimizing waste).

Hypothesis 1 is largely supported. Among construction SMEs that have already implemented at least one CE measure, reporting cost difficulties is positively and significantly associated with seven of the nine individual CE actions examined. The cost dummy is significant at $p<0.05$ in four models (saving water, minimizing waste, selling residues, and recycling) and marginally significant ($0.05 \leq p< 0.10$) in three models (saving energy, saving materials, and switching to greener suppliers of materials). No significant association is found for renewable energy or for designing products that are easier to maintain, repair or reuse. Hypothesis 2 regarding administrative complexity is only partially confirmed as it seems to be highly action specific. Difficulties related to technical requirements appear significant ($p<0.05$) mainly in the more systemic CE actions, such as designing products and switching to greener suppliers of materials, and marginally significant ($p<0.10$) for minimizing waste. Administrative or legal procedures are significant only for minimizing waste, which fits with the fact that construction waste is often regulated in detail at the local level. Environmental reporting difficulties are significant for saving materials and recycling. This is not surprising, because both actions require firms to measure and record their material flows. By contrast, environmental labelling & certification never reaches conventional significance, meaning that it does not emerge as a major difficulty for construction SMEs. Hypothesis 3 on expertise-related difficulties is also partially confirmed. First, the difficulty of adapting environmental legislation to the company is not significant in any model. Difficulty in choosing the right resource-efficiency actions is negatively significant for two technically demanding CE actions: renewable energy ($p<0.05$) and recycling ($p<0.05$). The results show that uncertainty about the "right" option still discourages these complex actions. Lack of specific environmental expertise is positively significant only for saving energy ($p<0.05$). The results seem to suggest that firms tend to notice the expertise gap after they start working on energy efficiency. Finally, Hypothesis 4 looks at the lack of market demand for resource efficient products or services and lack of supply of required materials and receives only limited support. Lack of supply of required materials, parts or services is statistically significant for saving water ($p<0.05$), saving energy ($p<0.05$) and designing products for repair or reuse ($p<0.05$). Lack of demand for resource-efficient products or services is significant only for saving energy ($p<0.05$) and marginally significant for saving materials ($p<0.10$). These findings contrast earlier studies that identified weak market demand and insufficient access to materials and services as key obstacles to CE adoption in the construction sector(Ababio & Lu, 2023; AlJaber, 2023; Durdyev et al., 2023; Munaro & Tavares, 2023; Osei-Tutu et al., 2023). A plausible explanation is that recent policy mechanisms, such as EU sustainability standards, green procurement, and subsidy schemes, have begun to alleviate these demand-side barriers for operational CE actions(Calzolari et al., 2021; Sajid et al., 2024). Moreover, internal motivations like cost reduction and regulatory compliance (Guldmann & Huulgaard, 2020). Lastly, the limited support for Hypothesis 4 may also, at least partly, reflect the low number of firms in our sample that have adopted more systemic CE practices. These findings may indicate that market and supply-related constraints become more relevant as firms move towards higher levels of circular maturity, aligning with Guldmann and Huulgaard (2020), who emphasizes the increasing importance of external factors in enabling systemic CE innovations.

Regarding the control variables, firm size shows the clearest pattern. The logarithm of employees is statistically significant in three models; renewable energy ($p<0.001$), switching to greener suppliers of materials ($p<0.05$) and Selling residues to other firms ($p<0.001$), and marginally significant ($p<0.10$) in two others (saving energy and waste minimization). In every case the coefficient is positive, indicating that larger construction SMEs are more likely to carry out the more resource-intensive or value-chain-oriented CE actions. Firm age is positive and significant only for renewable energy ($p<0.05$) and is unrelated to the other eight actions. The turnover dummy does not reach the 0.10 threshold in any model. Country fixed effects remain in all equations to capture national policy and market differences but are not interpreted here.

Table 5: Regression analysis of CE Actions and obstacles to implementation

Hypothesis & Barriers		**Model1**	**Model2**	**Model3**	**Model4**	**Model5**	**Model6**	**Model7**	**Model8**	**Model9**
		Saving Water	Saving Energy	Renewable Energy	Saving Materials	Green Supplier	Minimizing Waste	Selling Waster	Recycling	Designing Products
		B (p)	B (p)	B (p)	B (p)	B (p)	B (p)	B (p)	B (p)	B (p)
H1	Cost of CE actions	0,426 (0,002)	0,253 (0,087)	0,070 (0,644)	0,267 (0,078)	0,236 (0,089)	0,326 (0,043)	0,364 (0,009)	0,277 (0,039)	0,227 (0,105)
H2	Admin or Legal Procedure	0,069 (0,614)	0,272 (0,061)	-0,017 (0,912)	0,226 (0,128)	0,229 (0,100)	0,337 (0,033)	-0,109 (0,439)	0,113 (0,399)	0,064 (0,646)
	Technical Requirement	0,017 (0,909)	0,019 (0,909)	0,258 (0,111)	0,264 (0,116)	0,420 (0,005)	0,328 (0,071)	0,041 (0,785)	0,064 (0,659)	0,312 (0,035)
	Environmental Labeling & Certification	0,277 (0,070)	-0,026 (0,165)	0,229 (0,163)	-0,040 (0,815)	0,021 (0,891)	0,176 (0,337)	0,015 (0,923)	0,169 (0,255)	0,275 (0,068)
	Environmental Reporting	0,269 (0,068)	0,135 (0,395)	-0,175 (0,284)	0,343 (0,038)	-0,108 (0,472)	0,298 (0,091)	0,161 (0,283)	0,367 (0,011)	0,110 (0,460)
H3	Environmental Legislation	-0,031 (0,835)	-0,049 (0,759)	0,036 (0,826)	0,134 (0,422)	-0,190 (0,216)	-0,027 (0,876)	0,201 (0,185)	-0,105 (0,477)	-0,025 (0,869)
	Right Resource Efficiency Actions	0,032 (0,824)	-0,074 (0,637)	-0,391 (0,017)	0,145 (0,375)	-0,008 (0,957)	0,069 (0,686)	0,139 (0,337)	-0,342 (0,016)	0,052 (0,725)
	Environmental Expertise	0,151 (0,294)	0,414 (0,009)	0,109 (0,493)	-0,089 (0,574)	0,189 (0,196)	-0,052 (0,758)	0,017 (0,909)	-0,030 (0,833)	0,064 (0,659)

H4	Supply of materials	0,407 (0,003)	0,330 (0,028)	0,114 (0,453)	-0,029 (0,849)	0,126 (0,362)	-0,009 (0,955)	0,026 (0,851)	0,129 (0,340)	0,351 (0,011)
	Demand for RE product & Services	0,117 (0,416)	0,360 (0,023)	-0,117 (0,464)	0,318 (0,051)	-0,059 (0.685)	0,120 (0,480)	-0,094 (0,522)	0,071 (0,614)	0,170 (0,240)
	ln_Age	0,025 (0,710)	0,080 (0,237)	0,169 (0,023)	-0,038 (0,588)	-0,038 (0,578)	0,025 (0,730)	0,013 (0,848)	0,023 (0,719)	0,002 (0,976)
	ln_Employe e	0,052 (0,232)	0,081 (0,077)	0,165 (<0,001)	0,051 (0,272)	0,105 (0,023)	0,081 (0,099)	0,180 (<0.001)	0,041 (0,343)	-0,057 (0,217)
	Dummy Turnover	0,211 (0,153)	-0,098 (0,525)	-0,132 (0,399)	0,073 (0,646)	0,055 (0,719)	0,130 (0,437)	0,028 (0,856)	0,068 (0,637)	0,079 (0,609
	Country	Included	Included	Included	Included	Included	Included	Included	Included	Included
	-2 Log Likelihood	1.956,8	1.840,6	1.662,3	1.750,9	1.870,6	1.644,9	1.877,1	2.044,0	1.848,5
	Nagelkerke R^2	0,163	0,154	0,168	0,165	0,143	0,187	0,110	0,094	0,129
	Chi-Square	202,51	185,01	194,31	195,53	171,32	217,20	129,88	113,64	151,94

5. Discussion and Conclusion

The construction sector has been identified as an important sector for circular economy because it consumes large volumes of raw materials and generates large waste streams (Charef et al., 2021; Dsilva et al., 2023; Hoosain et al., 2021). However, quantitative evidence on how far SMEs in the construction sector have adopted circular practices is still limited. By analyzing 2,242 construction SMEs across the EU27, this study provides evidence on both adoption rates and perceived difficulties.

The descriptive analysis explores the first research objective: the extent of CE adoption among construction-sector SMEs. The findings reveal variation between the adoption of basic and more systemic resource-efficient practices. High implementation rates are observed in three CE actions by many SMEs: minimizing waste (64.5%), saving materials (60.8%) and saving energy (58.6%). These actions are often aligned with cost-saving or regulatory compliance motives and involve existing processes or relatively low disruption to existing workflows (Guldmann & Huulgaard, 2020; Kirchherr et al., 2017). In contrast, more systemic steps such as using predominantly renewable energy (26.3%) and designing products for easy repair or reuse (29.9%) remain considerably less adopted. This gap between basic and systemic CE actions likely reflects deeper organizational and strategic dynamics. Previous research suggests that SMEs often face structural constraints such as organizational inertia, risk aversion, short-term planning horizons (Guldmann & Huulgaard, 2020; Ranta et al., 2018; Ünal et al., 2019). Systemic CE actions often demand significant strategic reorientation, high upfront investment, technological upgrades, supply chain restructuring and long-term organizational commitment, which pose significant challenges for smaller firms (Guldmann & Huulgaard, 2020; Masi et al., 2017; Ünal et al., 2019). In addition to adoption levels, the data also capture which difficulties firms encountered when implementing CE practices. Nearly one-third of firms report administrative or legal complexity as a difficulty, and just under one-third point to the cost of environmental actions. These two difficulties rank highest among the reported difficulties, whereas lack of market demand is mentioned by fewer than one in five companies.

The regression analysis addresses the second research objective, namely identifying the main barriers to CE adoption, and provides additional nuance to the findings. Cost difficulties (H1) show a positive and significant association with seven of the nine actions, meaning that the companies that have already adopted these CE actions see cost as an important difficulty. Interestingly, the cost dummy is not significant for renewable energy or for product redesign, possibly because the low number of adopters in these two categories or because other factors overshadow cost once such projects are undertaken. Another possible explanation is that only financially stronger firms take on renewable energy and design products that are easier to maintain, repair or reuse, so these firms do not see cost as a major difficulty. Administrative barriers (H2) prove to be highly action-specific. Technical-requirement issues align with switching to green suppliers and product redesign, legal-procedure complexity links only to waste minimization, and reporting burdens arise when actions require careful material tracking, such as saving materials or recycling. Expertise-related difficulties (H3) are also selective. Difficulty in choosing the right option or lack of expertise discourages the technically demanding steps of installing renewable energy and setting up internal recycling systems, and to a lesser extent affects saving energy. Supply shortages (H4) are reported for saving water, saving energy, and designing products that are easier to maintain, repair or reuse, whereas demand gaps appear only for saving energy and saving materials.

Overall, it is concluded that cost difficulties are widespread. In seven of the nine models, firms that have taken a circular step also report that the cost of environmental actions is a notable difficulty. Cost pressure is therefore a common experience across most resource-efficiency measures. In addition, administrative difficulties seem to appear mainly where the action is already strongly regulated. In other words, administrative challenges are not general but concentrate around activities that are governed by existing local or EU standards.

6. Limitations

Several significant limitations must be acknowledged that restrict the analytical potential of the Flash Eurobarometer 549 survey dataset used in this paper. First, the data used in this study are cross-sectional, capturing firm behaviour and characteristics at a single point in time. This prevents us from drawing conclusions about causality. Nor can we observe how decisions evolve over time in response to CE related policies or internal strategies. Additionally, the firms that have not yet adopted any circular activity are excluded from the regression sample, limiting insight into first-entry barriers and may skew the sample toward more proactive or visible firms. Another issue arises from the use of self-reported data. As the Flash Eurobarometer relies on self-reported answers gathered by telephone interviews, the results may reflect perception bias rather than objective performance. This may introduce the risk of greenwashing, where firms might overstate their engagement with CE practices to align with sustainability narratives or policy expectations. This is particularly relevant in the construction sector, where high levels of informality and the presence of a shadow economy in certain regions increase the likelihood of both overreporting by formal firms and underreporting due to the exclusion of unregistered or informal actors from official surveys (see e.g., (Buehn & Schneider, 2012; Poniatowski et al., 2019; Schneider, 2015). These factors suggest that actual CE adoption may be significantly lower than reported, and the findings should be interpreted with this limitation in mind.

Beyond these structural issues, the dataset lacks the detailed institutional and legal information needed for cross-national regulatory analysis. It does not include direct indicators of regulatory frameworks, such as compliance thresholds, enforcement mechanisms, or legislative tools. It also lacks metadata, longitudinal markers, or connections to legal databases or recognized regulatory indices. Countries are represented only as binary dummy variables, serving as identifiers instead of analytical units that can capture institutional diversity. Even variables related to sustainability or policy knowledge depend on perceptions, making them unreliable proxies for national regulatory systems and risking ecological fallacies.

Moreover, the lack of a conceptual or typological framework to distinguish between regulatory instruments, such as command-and-control and market-based approaches, leaves the dataset poorly equipped for comparative policy research. All these methodological, structural, and conceptual limitations mean that the dataset is only suitable for analysing micro-level behaviour. Any attempt to draw cross-national regulatory differences from it would be methodologically invalid and scientifically indefensible.

7. Future Research Agenda

The limitations inherent in the Flash Eurobarometer 549 dataset, particularly its cross-sectional design, reliance on self-reported perceptions, and lack of institutional or legal granularity preclude comprehensive analysis of several critical dimensions relevant to CE transitions in the construction sector. This study has provided new insights into the adoption of CE practices across European construction SMEs, showing both the uneven uptake of basic versus systemic practices and the specific difficulties firms face. These contributions provide a clearer picture of the current state of CE adoption in the construction sector. At the same time, our results point to several directions for future research. We identify four broad areas that deserve closer examination. Future scholars should adopt a multi-level and cross-sectoral lens to elucidate the mechanisms, constraints, and enabling conditions underpinning effective CE implementation in heterogeneous regulatory environments that integrates longitudinal inquiry, policy design analysis, comparative institutional research, and market-embedded stakeholder dynamics in construction sector.

7.1. Longitudinal and Multi-Level Research Designs

The cross-sectional nature of the current dataset prevents the assessment of how CE engagement evolves over time or in response to shifting policy landscapes. Future research should therefore move beyond cross-sectional studies and adopt longitudinal research frameworks that track SMEs across multiple time periods, enabling scholars to examine causal pathways. Longitudinal data would also allow researchers to assess the long-term effects of CE policy interventions, for example by examining whether changes are temporary or result in lasting transformation. Comparative longitudinal research across industrial sectors could further clarify whether the drivers and barriers to CE adoption are specific to construction or apply more broadly. Moreover, comparative longitudinal studies across industrial sectors would clarify whether perceived enablers and constraints to CE adoption are construction-specific or generalizable across economic domains. Furthermore, the current dataset's exclusion of non-adopters highlights the need for research that captures the full adoption spectrum, from first-time entrants to systemic leaders and policy sequencing effects like whether incentive-first or regulation-first strategies lead to more durable CE transitions in construction sector. Employing mixed-method approaches, including panel surveys, qualitative interviews, and embedded case studies, will facilitate a deeper understanding of the interpretive processes through which firms navigate regulatory pressures, market demands, and internal change dynamics. Such methodological pluralism is critical for capturing the influence of organizational culture, leadership commitment, learning trajectories and informal institutional networks on CE uptake.

7.2 Comparative Institutional and Cross-National Analysis

While the present study cannot validly assess cross-national regulatory diversity due to the absence of institutional variables, our review of the literature suggests that national context plays a significant mediating role in CE policy effectiveness. Future research should be explicitly designed to investigate how institutional configurations, such as regulatory design, enforcement capacity, and administrative culture condition the translation of EU-level CE directives into firm-level practice. Further, policy coherence between EU-level directives and national implementations must be empirically examined, particularly in contexts where fragmentation or misalignment impedes effective execution. Cross-national studies comparing high and low-adoption Member States can yield critical insights into the institutional conditions, such as administrative quality, enforcement capacity, and stakeholder engagement that facilitate or obstruct systemic CE transitions. Moreover, research that maps Member States' CE readiness, including infrastructure, labour markets, and supply chain capacities, could help identify region-specific constraints and policy priorities. Finally, future work should use more detailed institutional data, including legal indicators, types of regulatory instruments (e.g. market-based versus command-and-control) and enforcement mechanisms, rather than relying only on proxies. This would allow more precise and reliable cross-country analyses.

7.3 Governance Effectiveness and Policy Tool Evaluation

The Flash Eurobarometer lacks the granularity required to distinguish between different CE governance models or to evaluate the effectiveness of specific policy instruments. Future research should therefore examine how different forms of regulation and support measures influence CE adoption in practice. An important gap is the limited understanding of how policymakers themselves view CE challenges and opportunities, and how these views shape the policies they design. Studies should also explore how different tools, such as regulatory mandates, fiscal incentives, green procurement, and infrastructure investments, work together and whether their combined effects are reinforcing or contradictory.

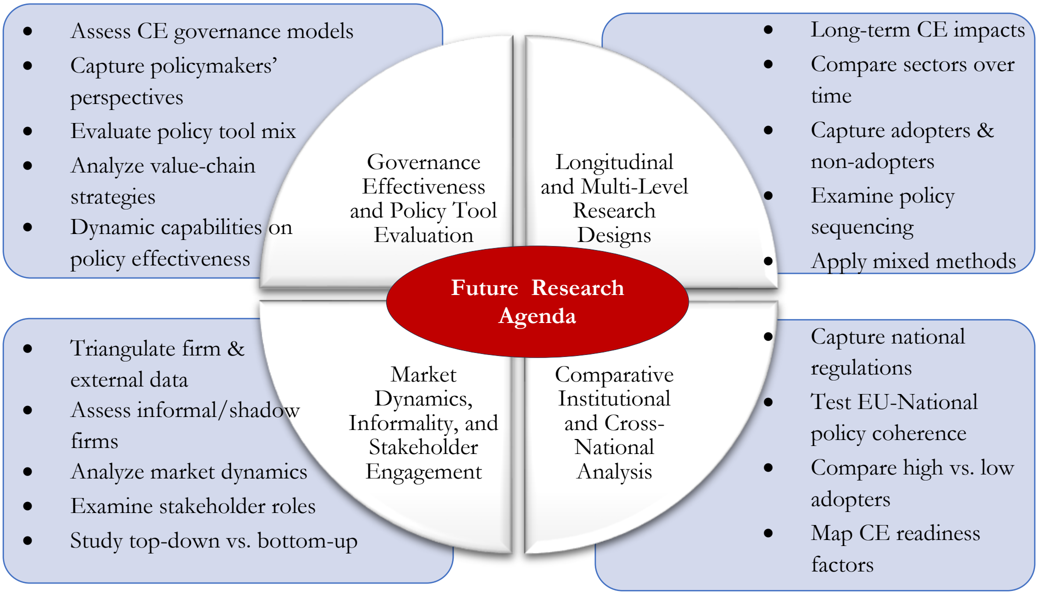
Particular attention should be paid to Sustainable Consumption and Production strategies that span both upstream and downstream phases of the construction value chain. Additionally, future research should examine how organizational dynamic capabilities, such as absorptive capacity, technological agility, and inter-organizational collaboration mediate the effectiveness of these policy instruments across different regulatory environments.

7.4 Market Dynamics, Informality, and Stakeholder Engagement

Given the risk of perception bias and potential greenwashing in self-reported datasets, particularly in sectors such as construction, future studies must triangulate firm-reported data with observational, administrative and third-party verification sources. Research is needed to examine how informal practices, unregistered firms, and shadow economies influence both the visibility and the actual scale of CE activity that are systematically underrepresented in formal surveys. Moreover, studies should explore how market conditions like supply-demand imbalances, procurement systems, and consumer awareness shape the viability of CE business models. Stakeholder co-responsibility, including the role of civil society, industry associations, and public-sector actors, should be analysed to understand how bottom-up initiatives interact with top-down regulatory frameworks to drive systemic sectoral transformation.

This future research agenda is thus not only informed by gaps in the existing literature but also arises by the limitations of the present study. Addressing these limitations through more robust data collection, conceptual refinement, and methodological diversification will be essential for advancing CE research and policy, particularly in a sector as complex and institutionally embedded as construction.

Figure 1: Proposed Future Research Agenda



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