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The Role of the Private Sector and MSMEs in Advancing the Circular Economy in Arid Metropolitan Regions

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Abstract

The circular economy (CE) has emerged as a central policy framework for advancing sustainable urban development; however, empirical evidence regarding the role of micro, small, and medium-sized enterprises (MSMEs) in metropolitan CE transitions remains limited, particularly in arid regions. This study examines how private sector firms and MSMEs engage with CE practices within an arid metropolitan context, using the Dammam Metropolitan Area (Saudi Arabia) as an illustrative case study. Adopting a place-based and governance-sensitive analytical perspective grounded in urban studies scholarship, the research employs a structured quantitative survey of 180 firms across key urban–industrial sectors. The analysis investigates levels of CE awareness, adoption patterns, perceived barriers, support needs, and future expectations. The findings indicate that MSMEs primarily engage in resource-based and efficiency-oriented circular practices, while more systemic models, such as supply-chain integration and platform-based circular solutions, remain limited. Moreover, capability-related factors, particularly skills and technological capacity, exert a stronger influence on adoption than awareness alone. Importantly, the study identifies a high level of latent willingness among MSMEs to invest in circular practices under supportive policy and institutional conditions. The discussion reframes CE transitions as governance-mediated urban development processes, emphasizing the importance of metropolitan coordination, institutional capacity-building, and shared spatial infrastructure. By grounding the analysis in the case of the Dammam Metropolitan Area, the study contributes to urban studies and CE scholarship by positioning MSMEs as conditionally willing system-building actors whose engagement is essential for advancing inclusive and place-sensitive circular transitions in arid metropolitan regions.

Keywords: circular economy; MSMEs; urban sustainability; metropolitan governance; arid regions; private sector; circular transition; Urban Studies; sustainable development



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1. Introduction

The circular economy (CE) has emerged as a prominent framework within global sustainability policy and urban development agendas, frequently presented as a pathway to reconcile economic growth with environmental sustainability. By emphasizing material circularity, waste valorization, and resource efficiency, CE strategies aim to reduce resource extraction and minimize environmental externalities associated with linear production systems [1–3]. Over the past decade, CE has been increasingly incorporated into national sustainability strategies, urban policy frameworks, and corporate innovation agendas [4–6]. However, a growing body of critical scholarship argues that CE should not be understood solely as a technical solution to environmental challenges. Instead, circular

transitions are shaped by institutional arrangements, governance structures, and broader political–economic dynamics that influence how circular practices are implemented across different territories and economic sectors [7–9].

Within urban studies, cities and metropolitan regions have become central arenas for the implementation of circular economy strategies. Urban areas concentrate infrastructure systems, material flows, labor markets, and governance capacities, making them critical sites for experimenting with circular resource management and industrial symbiosis initiatives [10,11]. Yet circular transitions rarely unfold as purely technological processes. Instead, they are embedded in metropolitan governance arrangements, historical industrial legacies, and spatial power relations that shape the distribution of opportunities and constraints among economic actors [12,13]. From this perspective, circular economy transitions must be understood as place-based processes, mediated through urban political economies rather than universally transferable policy models.

These dynamics are particularly pronounced in arid metropolitan regions, where environmental constraints intersect with rapid urbanization and industrial development. Arid regions frequently experience structural pressures related to water scarcity, energy-intensive production systems, and rising waste generation associated with expanding urban populations and industrial clusters [14,15]. At the same time, many arid metropolitan areas function as strategic industrial and logistics hubs integrated into global value chains, generating significant material throughput and environmental stress [16–19]. Despite the urgency of circular transitions in these contexts, empirical research examining how CE strategies operate within arid metropolitan economies remains limited.

Within the broader CE literature, the private sector is widely recognized as a key driver of circular innovation, production systems, and resource management practices [20–22]. However, urban studies scholarship highlights the importance of distinguishing between different categories of firms and their spatial embeddedness within metropolitan economies. In particular, micro, small, and medium-sized enterprises (MSMEs) play a foundational role in many urban economic systems. MSMEs account for a substantial share of employment, service provision, and localized innovation within metropolitan regions, positioning them as potentially important actors in advancing circular practices such as repair, recycling, reuse, and resource-efficient production [23–25].

Nevertheless, empirical evidence consistently demonstrates that MSMEs face structural barriers when adopting circular economy practices. Limited access to finance, regulatory complexity, fragmented policy support systems, and insufficient technical capacity often constrain MSME participation in CE initiatives [3,8,23]. Moreover, critical scholars have argued that dominant CE narratives frequently privilege capital-intensive technological solutions and large corporate actors capable of absorbing transition costs, potentially marginalizing smaller firms that are deeply embedded in local economic systems [7,9–11]. This dynamic raises important questions regarding the distribution of opportunities and benefits associated with circular transitions and whether CE policies risk reinforcing existing inequalities within metropolitan economies.

Recent urban research also emphasizes the multi-scalar governance dynamics shaping CE implementation. While circular economy strategies are often formulated at national or metropolitan policy levels, their practical realization depends on firm-level decisions and localized governance arrangements [5,10,13–15]. This scalar mismatch can create implementation gaps, particularly for MSMEs operating in fragmented urban economies or peripheral industrial zones. Without effective institutional coordination and targeted policy instruments, CE initiatives risk remaining symbolic policy frameworks rather than generating substantive transformations in urban production systems [3,8,23].

These challenges are further intensified in many arid metropolitan regions characterized by state-led development strategies and infrastructure-driven urban growth. While such contexts frequently exhibit strong policy ambition and strategic planning capacity, translating circular economy visions into inclusive and actionable outcomes at the level of MSMEs remains uneven [8,26–28]. Studies examining CE initiatives in Gulf countries and other arid regions point to persistent challenges related to regulatory fragmentation, limited coordination between public and private actors, and uneven institutional support for smaller firms [13–15,29]. These findings underscore the importance of empirically grounded research examining how CE policies are experienced and enacted by firms operating within metropolitan economic systems.

Against this backdrop, the present study investigates the role of the private sector and MSMEs in advancing circular economy practices in arid metropolitan regions, using the Dammam Metropolitan Area (Saudi Arabia) as an empirical case study. The Dammam Metropolitan Area, comprising Dammam, Dhahran, Al Khobar, and Qatif, represents one of the largest industrial and logistics clusters in the Gulf region, characterized by petrochemical industries, manufacturing activities, logistics networks, and rapidly expanding urban infrastructure [19–30]. By examining firm-level engagement with circular practices such as waste reduction, recycling, resource efficiency, and sustainable production, the study seeks to bridge the gap between macro-level CE policy narratives and micro-level implementation dynamics within metropolitan economies.

Methodologically, the study employs a structured quantitative survey of MSMEs operating in key urban-industrial sectors to analyze levels of CE awareness, adoption patterns, perceived barriers, and enabling policy conditions. By situating MSME behavior within metropolitan governance structures, regulatory frameworks, and regional political economies, the research advances a more nuanced understanding of circular transitions as governance-mediated and context-dependent processes rather than universally replicable sustainability solutions.

The remainder of the paper is organized as follows. Section 2 reviews the conceptual and empirical literature on circular economy transitions, focusing on urban governance, MSME participation, and regional political economy. Section 3 outlines the research methodology. Section 4 presents the empirical findings. Section 5 discusses the implications for circular economy governance in arid metropolitan regions, and the final section concludes with reflections on limitations and future research directions.

2. Literature Review

The concept of the circular economy has evolved substantially over the past three decades, reflecting contributions from multiple disciplinary traditions including industrial ecology, environmental economics, and sustainability studies. Early conceptualizations emerging in the 1990s and early 2000s primarily focused on closing material loops through practices such as recycling, reuse, and remanufacturing. These approaches emphasized efficiency gains within existing production systems and were largely grounded in engineering and waste management perspectives [1,6,15]. During this phase of conceptual development, CE was frequently framed as a technological solution capable of optimizing resource flows while maintaining economic growth trajectories.

By the mid-2010s, however, scholars began to highlight conceptual limitations in this technocratic framing of circular economy strategies. Systematic reviews of CE definitions revealed a strong emphasis on material flows and efficiency improvements, with comparatively limited attention paid to institutional arrangements, social relations, or political-economic dynamics shaping circular transitions [3,7,31]. In response, more recent

research has increasingly conceptualized CE as a broader socio-economic transformation rather than a purely technical innovation.

Critical scholars argue that circular economy strategies are embedded within broader economic systems characterized by growth imperatives, uneven power relations, and institutional constraints [5,21,26]. From this perspective, CE initiatives risk reproducing the underlying logic of linear production systems if they focus primarily on efficiency improvements without addressing deeper structural issues such as consumption patterns, distributional equity, and environmental limits. Within urban studies, these debates have led to the recognition that circular transitions must be understood as urban development processes shaped by governance arrangements, spatial inequalities, and metropolitan political economies [7–9].

A key conceptual distinction emerging from this literature concerns the difference between incremental resource-efficiency practices and systemic circular transformations. Resource-efficiency measures, such as recycling, waste reduction, and energy efficiency improvements, can reduce environmental pressures but typically operate within existing economic structures. In contrast, systemic circular transformations involve more fundamental changes in production systems, business models, and governance arrangements, including industrial symbiosis, circular supply chains, product-service systems, and collaborative sharing platforms [23,31,32]. Understanding how these different forms of circularity emerge in practice is therefore critical for evaluating the transformative potential of CE strategies.

Cities and metropolitan regions have increasingly become focal points for circular economy implementation because they concentrate infrastructure systems, material flows, economic activity, and governance institutions. The concept of the “circular city” highlights the role of urban planning, industrial symbiosis, and metropolitan governance in enabling circular resource management systems [8,18,33]. Empirical studies, particularly those conducted in European metropolitan regions, demonstrate that urban CE initiatives are strongly shaped by local institutional arrangements, historical development trajectories, and regional economic structures [9,34]. As a result, circular economy strategies tend to be highly place-specific rather than universally transferable policy models.

Urban studies scholarship further emphasizes that CE initiatives are often unevenly distributed within metropolitan spaces. Circular projects frequently concentrate in well-resourced urban cores, flagship development zones, or formal industrial clusters, while peripheral areas, informal sectors, and smaller firms remain marginal to circular initiatives [17,35]. This spatial unevenness raises important concerns regarding accessibility, employment distribution, and social inclusion within circular transitions. Scholars increasingly argue that place-based governance plays a decisive role in mediating CE outcomes, as local institutions shape how policies interact with land use systems, labor markets, and industrial networks [10–13].

Despite the rapid expansion of urban CE literature, arid metropolitan regions remain underrepresented in empirical research. These regions face distinctive structural conditions including water scarcity, high energy demand, limited recycling infrastructure, and dependence on resource-intensive industrial sectors [8,12]. Such conditions simultaneously heighten the urgency of circular strategies while complicating their practical implementation. Research focusing on Gulf countries and other arid regions suggests that CE initiatives are frequently driven by state-led development strategies linked to industrial diversification and environmental resilience agendas [13,14,27]. However, these policy frameworks often prioritize large-scale infrastructure investments and major industrial actors, providing limited insight into how circular principles are implemented by smaller firms embedded in metropolitan economies [5,29].

Within this context, MSMEs play a particularly important role. Due to their numerical dominance and strong local embeddedness, MSMEs contribute significantly to employment creation, service provision, and localized innovation processes in metropolitan economies [8,18]. Their proximity to local markets and integration into urban production networks position them as potential drivers of circular practices such as repair services, reuse activities, recycling operations, and resource-efficient manufacturing. However, empirical studies consistently demonstrate that MSMEs face disproportionate barriers to CE adoption compared with larger firms. These barriers include financial constraints, regulatory complexity, technological limitations, and insufficient access to policy support programs [15,36–38].

In metropolitan economies, these challenges are often exacerbated by spatial fragmentation. MSMEs frequently operate in dispersed industrial zones or peripheral urban areas where access to shared infrastructure and collaborative networks is limited, constraining opportunities for industrial symbiosis and coordinated circular solutions [10,39,40]. At the same time, dominant CE narratives often privilege large firms capable of absorbing transition costs and navigating complex regulatory environments, potentially reinforcing existing power asymmetries within urban economic systems [8,21,26].

Circular transitions are therefore shaped by multi-scalar governance arrangements linking national policy frameworks, metropolitan planning systems, and firm-level decision-making processes. While CE policies are frequently articulated at national or regional levels, their practical implementation depends on local institutional capacity and private sector engagement [8,23,37]. In arid metropolitan regions characterized by strong state involvement in economic planning, centralized governance structures may accelerate policy diffusion but may also limit bottom-up innovation and MSME participation if policy instruments are not sufficiently adapted to local business realities [35].

Recent research increasingly emphasizes the need for coordinated policy mixes combining regulatory frameworks, financial incentives, capacity-building programs, and stakeholder engagement mechanisms to support circular transitions [17–20,29]. From an urban political economy perspective, these governance arrangements shape not only environmental outcomes but also labor markets, firm survival, and spatial inequalities within metropolitan regions [22,34,39–43]. Consequently, analyzing CE transitions requires an integrated analytical framework that connects firm-level behavior with broader metropolitan governance structures and regional economic systems.

Taken together, the existing literature reveals three key gaps. First, empirical research examining circular economy implementation in arid metropolitan regions remains limited. Second, MSMEs remain underexplored as active agents of circular transitions despite their central role in metropolitan economies. Third, many existing studies overlook the governance and scalar dynamics shaping MSME participation in CE initiatives. Addressing these gaps, the present study examines how private sector firms and MSMEs engage with circular economy practices in an arid metropolitan context, using the Dammam Metropolitan Area as a case study. By integrating firm-level evidence with insights from urban governance and regional political economy, the study contributes to ongoing debates on sustainability transitions, spatial inequality, and place-based circular economy policy design.

3. Methodology

This study adopts a quantitative, cross-sectional research design to examine the role of the private sector and micro, small, and medium-sized enterprises (MSMEs) in advancing circular economy (CE) practices within arid metropolitan regions. Consistent with urban studies scholarship, the methodological approach is explicitly place-based and governance-sensitive,

recognizing that circular economy transitions are shaped by local institutional arrangements, sectoral structures, and metropolitan political economies rather than by universally replicable mechanisms [7,8,11–15]. Rather than conceptualizing CE adoption as a purely technical or firm-internal decision, the study situates MSME behavior within broader urban–regional contexts, regulatory environments, and policy frameworks [44–47]. This analytical framing responds to calls for empirical approaches capable of bridging macro-level CE strategies with micro-level implementation realities, particularly in resource-constrained and arid metropolitan settings where sustainability transitions are mediated by institutional capacity and governance structures [7,13,48–50].

The empirical analysis focuses on the Dammam Metropolitan Area (DMA) in Saudi Arabia, which serves as the case study for examining CE dynamics in an arid metropolitan context. The DMA comprises a complex urban–industrial system including the cities of Dammam, Dhahran, Al Khobar, and Qatif. The region hosts major clusters in manufacturing, petrochemicals, logistics, construction, and service industries while experiencing rapid urban expansion and infrastructure development (Figure 1). As is typical of arid metropolitan regions, the study area faces acute sustainability challenges related to water scarcity, energy-intensive industrial activity, increasing waste generation, and pressures on land-use systems [18,19]. These structural conditions heighten the relevance of circular economy strategies aimed at improving resource efficiency and reducing environmental impacts [51–55]. Within this context, the Dammam Metropolitan Area provides an appropriate empirical setting for examining how CE policies and practices are mediated through metropolitan governance arrangements and private sector dynamics [17,26]. Importantly, the case is not treated as an exceptional example but rather as an illustrative instance situated within broader debates on arid-region urbanization, state-led development, and sustainability transitions central to Urban Studies research.

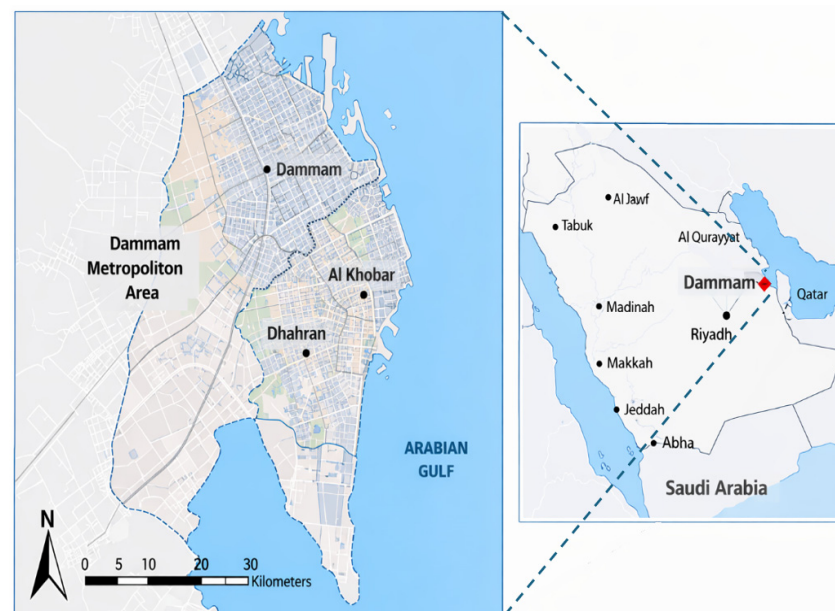


Figure 1. Geographical Location of Dammam Metropolitan Area, Saudi Arabia (adapted by the author based on geographic data and contextual reference from [19]).

Primary data were collected through a structured questionnaire survey administered to MSMEs and private sector firms operating across key economic sectors within the metropolitan region. The survey instrument was designed to capture firm-level engagement with circular economy practices while simultaneously assessing perceived barriers, enabling factors, and policy influences shaping CE adoption. The questionnaire included

several components. First, information on firm characteristics was collected, including firm size, sector, years of operation, and ownership structure. Second, respondents reported their engagement with CE practices such as waste reduction, recycling, resource efficiency, and sustainable production processes. Third, the survey assessed perceived barriers to CE adoption, including financial constraints, regulatory complexity, technological limitations, and market uncertainty. Fourth, respondents evaluated enabling factors and policy instruments, including regulatory frameworks, financial incentives, and institutional support mechanisms. Finally, firms assessed metropolitan governance conditions, particularly the clarity, coordination, and effectiveness of policies supporting circular economy initiatives.

Survey items were measured using Likert-scale responses to capture variations in perception, intensity of engagement, and institutional assessment. Likert-scale instruments are widely used in firm-level sustainability and circular economy research because they allow systematic measurement of attitudes, perceptions, and reported practices across diverse economic actors [6,8,10,21,23,39–45]. The survey instrument was refined through expert review to ensure conceptual clarity, contextual relevance, and consistency with regulatory and institutional terminology specific to arid metropolitan governance environments.

Given the absence of a comprehensive public registry identifying CE-active MSMEs in the region, the study employed a purposive sampling strategy targeting firms across manufacturing, logistics, construction, services, and related urban-industrial sectors. These sectors were selected because of their material intensity, waste generation potential, and relevance to circular economy implementation in metropolitan economies. The sampling process was complemented by outreach through business associations, industrial zones, and professional networks. This approach aligns with urban studies research practices that prioritize analytical relevance and contextual depth when examining emerging sustainability transitions within metropolitan systems [39–45].

The target population consisted of 250 MSMEs operating within the metropolitan region. Based on comparable firm-level surveys conducted in Gulf Cooperation Council (GCC) contexts, a response rate of approximately 70–80% was anticipated [18,19,56]. The study achieved a response rate of 72%, resulting in a final dataset of 180 valid responses used for empirical analysis. This response rate is consistent with best practice standards for firm-level survey research in urban and regional policy studies [57].

Quantitative data analysis combined descriptive and inferential statistical techniques. Descriptive statistics were first used to examine the prevalence and distribution of circular economy practices across sectors and firm sizes, providing an overview of MSME engagement within the metropolitan economy [57,58]. To identify underlying dimensions of CE adoption barriers, exploratory factor analysis (EFA) was conducted using principal component analysis with varimax rotation. Sampling adequacy was evaluated using the Kaiser–Meyer–Olkin (KMO) statistic, and Bartlett’s test of sphericity was applied to confirm the suitability of the data for factor analysis following established methodological standards [58–60]. Regression analysis was subsequently employed to explore relationships between firm characteristics, policy-related variables, and levels of circular economy engagement, enabling the identification of statistically significant associations while remaining attentive to the structural and governance conditions emphasized in urban studies scholarship [32,37,50–55].

The use of survey-based methods in this study reflects a growing recognition within urban and regional research that firm-level surveys provide valuable insights into how sustainability policies and institutional frameworks are experienced by economic actors embedded within metropolitan systems [47,53,54]. While urban political economy research has traditionally relied on qualitative institutional analysis, survey approaches offer complementary empirical evidence regarding firm perceptions, behavioral responses, and policy

interactions shaping sustainability transitions [12,20,41,42]. In the context of circular economy implementation, where adoption depends heavily on firm behavior, institutional trust, and policy credibility, survey data provide an important bridge between macro-level policy narratives and micro-level implementation dynamics within metropolitan economies.

Similarly, the regression analysis employed in this study should be interpreted as an exploratory analytical tool rather than as a predictive model of circular economy adoption. Circular transitions are influenced by complex interactions among institutional, regulatory, technological, and market conditions that cannot be fully captured within a single statistical model. Consequently, the regression results are intended to highlight indicative patterns and associations between explanatory variables and firm-level practices rather than to provide deterministic explanations of CE adoption. This exploratory approach is consistent with empirical research on sustainability transitions and innovation adoption, where statistical models are frequently used to identify emerging dynamics and inform future research directions [3,6,8,11–15,21,23,39–45].

In interpreting the results of the exploratory factor analysis, Cronbach's alpha coefficients were calculated to assess internal consistency among grouped variables [58]. While most factors demonstrated acceptable reliability levels, one dimension associated with knowledge and financial barriers produced a lower alpha value. This outcome likely reflects the conceptual heterogeneity of constraints faced by MSMEs, where financial limitations, knowledge gaps, and institutional constraints coexist but do not necessarily form a tightly integrated latent construct. Similar patterns have been observed in exploratory studies of sustainability adoption among small firms, where barriers often represent multidimensional and context-dependent challenges rather than unified psychometric scales. This interpretation follows recommendations in exploratory factor analysis where lower reliability scores may occur when factors capture heterogeneous policy or institutional constraints [58–60]. The factor was therefore retained for analytical purposes as an indicative grouping of related constraints rather than as a strictly cohesive scale.

Consistent with critical urban research practices, several methodological limitations are acknowledged. First, the cross-sectional design captures MSME perceptions and practices at a single point in time, limiting the ability to observe temporal dynamics associated with circular economy transitions. Second, the empirical analysis relies on self-reported survey data, which may introduce response bias. In particular, respondents may overreport environmentally desirable practices due to social desirability effects or perceived expectations associated with sustainability policies. To mitigate this risk, the survey emphasized anonymity and confidentiality to encourage accurate reporting of firm practices and perceptions. Nevertheless, the possibility of social desirability bias remains a limitation that should be considered when interpreting the findings. Third, although the study adopts a place-based analytical perspective, it does not explicitly capture informal economic activities that may contribute to circular practices in certain metropolitan contexts. Informal repair, reuse, and recycling activities can play an important role in urban circular economies, particularly in developing or rapidly urbanizing regions [12,20,33–41]. These limitations reflect broader methodological challenges associated with studying emerging sustainability transitions within complex metropolitan systems.

Participation in the survey was voluntary, and respondents were assured of confidentiality and anonymity. Data collection and analysis were conducted in accordance with established ethical research standards, ensuring that firm-level information was used exclusively for academic research purposes.

By integrating firm-level quantitative analysis with a place-based and governance-sensitive framework, the methodology contributes to advancing urban studies approaches to circular economy research. Rather than treating CE adoption as a purely techno-

logical or firm-internal decision, the study foregrounds the institutional, spatial, and political–economic conditions shaping MSME engagement in circular practices within arid metropolitan regions, demonstrating how quantitative methods can be mobilized within a critical urban analytical framework to better understand sustainability transitions in metropolitan economies.

Beyond its empirical findings, this study contributes methodologically to emerging research on circular economy transitions in metropolitan contexts. By combining firm-level survey analysis with a place-based urban political economy perspective, the approach demonstrates how quantitative methods can be used to examine sustainability transitions while remaining attentive to institutional and territorial dynamics. In particular, the study illustrates how survey-based evidence can help bridge macro-level circular economy policy frameworks with the micro-level experiences of firms embedded in metropolitan economies. This methodological integration provides a practical framework for analyzing circular economy adoption among MSMEs in other arid and resource-constrained urban regions.

4. Results

4.1. Profile of Respondents

This subsection presents the general characteristics of the surveyed firms and examines how sectoral structure, firm size, and metropolitan location shape the composition of the sample. Consistent with Urban Studies scholarship, these characteristics are interpreted not merely as descriptive attributes but as indicators of broader metropolitan political–economic structures that influence firms' capacity to engage in circular economy (CE) practices [8,11]. The analysis therefore situates firm-level characteristics within the institutional and spatial context of the Dammam Metropolitan Area, providing a structural foundation for understanding patterns of CE adoption across sectors and locations.

As shown in Table 1, the survey sample ($n = 180$) reflects a heterogeneous but MSME-dominated metropolitan economy. Firms operating in service-oriented activities (21.7%), including professional services, maintenance, and technical support services, represent the largest share of respondents. This is closely followed by manufacturing firms (21.1%), which include small-scale industrial production, fabrication, and processing activities linked to the broader petrochemical and industrial ecosystem of the region. Tourism-related enterprises (20.0%), encompassing hospitality, leisure services, and tourism support activities, also constitute a substantial share of the sample, reflecting the growing diversification of economic activities within the metropolitan region. Additional sectors represented include real estate and property development activities (16.7%), trade and commercial distribution firms (12.2%), and a smaller group of other activities (8.3%) that include logistics support services and specialized business operations. This sectoral composition illustrates the coexistence of material-intensive industries and service-based activities within the metropolitan economy, a pattern frequently observed in urban CE research where different sectors exhibit varying capacities and opportunities for circular practices [9,18,50].

With respect to firm size, the sample strongly reflects the structural dominance of MSMEs within metropolitan economies. Micro-enterprises (30.0%) and small firms (23.9%) together account for more than half of all respondents, confirming the MSME orientation of the dataset. Medium-sized firms represent 24.4%, while large enterprises account for 21.7% of the sample. The mean coded firm size ($M = 2.37$, $SD = 1.01$) lies between the micro and small firm categories, reinforcing the analytical relevance of focusing on MSMEs as locally embedded but resource-constrained actors within metropolitan economic systems. These findings align with urban political economy perspectives that highlight MSMEs as central

participants in urban economies while simultaneously facing structural disadvantages in sustainability transitions dominated by large corporate actors [35,45,50].

Table 1. General Information: Profile of Respondents ($n = 180$).

(a) Profile of Respondents with Mean and Dispersion					
Variable	Category	n	%	Mean	SD
Type of Business Activity	Manufacturing	38	21.1	3.42	1.71
	Services	39	21.7		
	Trade	22	12.2		
	Tourism	36	20.0		
	Real Estate	30	16.7		
	Other	15	8.3		
Firm Size (Employees)	Micro (1–9)	54	30.0	2.37	1.01
	Small (10–49)	43	23.9		
	Medium (50–249)	44	24.4		
	Large (250+)	39	21.7		
Location (DMA)	Dammam	63	35.0	2.94	1.63
	Dhahran	30	16.7		
	Al Khobar	24	13.3		
	Qatif	21	11.7		
	Ras Tanurah	30	16.7		
	Other	12	6.6		
(b) Chi-Square Tests of Independence					
Relationship Tested	χ^2	df	p-Value	Interpretation	
Business Activity $\times$ Metropolitan Location	9.84	10	0.45	Not significant	
Firm Size $\times$ Metropolitan Location	18.62	10	0.046 *	Significant	
Business Activity $\times$ Firm Size	21.37	15	0.13	Not significant	
(c) One-Way ANOVA: Firm Size by Business Activity Type					
Source of Variation	Sum of Squares	df	Mean Square	F	p-Value
Between Groups	42.18	5	8.44	4.12	0.002 **
Within Groups	356.41	174	2.05		
Total	398.59	179			

Note: Means and standard deviations are based on coded categories and are reported for descriptive purposes only. Significance: $p < 0.01$ ** and $p < 0.05$ *.

From a spatial perspective, the distribution of firms across the metropolitan area reflects the multi-nodal structure of the Dammam Metropolitan Area. Firms are most strongly concentrated in Dammam (35.0%), the metropolitan core and primary industrial and commercial hub. Additional concentrations appear in Dhahran (16.7%) and Ras Tanurah (16.7%), both of which host important industrial and energy-related activities. Al Khobar (13.3%) and Qatif (11.7%) also contribute a significant share of firms, while other peripheral locations account for 6.6% of respondents. The mean coded location value ($M = 2.94$, $SD = 1.63$) indicates a spatial distribution that captures both core urban centers and secondary industrial locations within the metropolitan region. This spatial spread is analytically significant, as prior urban studies research demonstrates that opportunities for CE adoption are often spatially differentiated across metropolitan areas due to uneven access to infrastructure, markets, and governance support systems [10,34,39].

To examine whether firm characteristics are unevenly distributed across metropolitan space, chi-square tests of independence were conducted. The results reveal a statistically significant relationship between firm size and metropolitan location ($\chi^2 = 18.62$, $p = 0.046$),

indicating that MSMEs and larger firms are not evenly distributed across the metropolitan area. This pattern is consistent with urban economic research showing that firm size and industrial activity tend to cluster spatially according to historical development trajectories, infrastructure availability, and zoning policies [10,17]. In contrast, the association between business activity type and metropolitan location was not statistically significant, suggesting that sectoral diversity is relatively dispersed across the metropolitan region. This finding supports arguments that contemporary metropolitan economies increasingly exhibit multi-sectoral and mixed-use spatial configurations rather than strict sectoral segregation [11–15].

To further investigate structural differences across sectors, a one-way analysis of variance (ANOVA) was conducted to assess whether average firm size differs by business activity type. The results indicate statistically significant differences in mean firm size across sectors ($F = 4.12, p = 0.002$). Post-hoc comparisons suggest that manufacturing and real estate firms tend to employ larger workforces compared with firms in services and trade-related activities. This result is consistent with insights from circular economy and urban political economy literature, which emphasize that sectoral position often influences firms' resource capacity, investment horizons, and ability to implement circular practices [15,21]. In metropolitan CE transitions, such sectoral differences are particularly relevant, as larger and more capital-intensive firms typically face fewer barriers to technological upgrading and regulatory compliance than smaller service-oriented enterprises.

Overall, the findings presented in this subsection confirm that the surveyed firms operate within a structurally differentiated metropolitan economy characterized by sectoral diversity, spatial clustering, and a strong MSME presence. These structural conditions provide an important contextual foundation for understanding patterns of circular economy adoption among firms operating in the metropolitan region. Consistent with Urban Studies scholarship, the results suggest that CE engagement cannot be interpreted independently of metropolitan economic structures, spatial inequalities, and firm-level resource capacities [7,11]. The observed heterogeneity across sectors, firm sizes, and locations therefore underscores the importance of accounting for metropolitan political-economic context when evaluating private sector participation in circular economy transitions within arid metropolitan regions.

4.2. Awareness and Perceptions of the Circular Economy

This subsection examines firms' awareness of the circular economy (CE), their perceptions of its relevance to business operations, and the extent to which specific circular practices are currently implemented. In line with Urban Studies scholarship, awareness and perception are interpreted not simply as individual attitudes but as outcomes shaped by sectoral positioning, firm capacity, and metropolitan political-economic structures that condition how sustainability narratives circulate within urban economies [8,11]. Understanding these perceptions is therefore essential for assessing how CE concepts translate from policy discourse into practical engagement among firms operating within metropolitan systems.

The results indicate a relatively high level of awareness of CE among surveyed firms. As shown in Table 2, nearly three-quarters of respondents (73.3%) reported that they had heard of the CE concept, while 26.7% indicated no prior familiarity. This finding suggests that circular economy discourse has achieved substantial visibility within the metropolitan private sector, reflecting the diffusion of sustainability narratives through policy initiatives, institutional channels, and business networks. Similar patterns of widespread awareness have been observed in metropolitan regions where sustainability agendas are actively promoted through government programs and industry partnerships [36,37]. However, Urban Studies scholars caution that awareness alone does not necessarily translate into

meaningful structural change. Instead, awareness may coexist with limited capacity for implementation, particularly among MSMEs operating under financial, regulatory, and infrastructural constraints [5,21].

Respondents were also asked to evaluate the relevance of CE to their business activities. Overall perceptions were positive, with most firms rating CE as moderately relevant, relevant, or highly relevant to their operations. The mean relevance score ($M = 3.64$, $SD = 1.18$) indicates a generally favorable orientation toward circular economy principles, although responses display considerable variation across firms. This variation reflects findings in the broader CE literature, which suggest that firms' perceptions of circular economy relevance are influenced by sectoral exposure to material flows, regulatory pressures, and anticipated cost structures [15,16]. From an Urban Studies perspective, such heterogeneity highlights the uneven embedding of sustainability agendas within metropolitan economies, where firms differ substantially in their production logics, strategic horizons, and regulatory environments [9–11].

Despite relatively high levels of awareness and perceived relevance, the adoption of circular economy practices remains uneven across firms. As indicated in the analysis, the most commonly reported practices include recycling waste materials (56.1%) and implementing resource efficiency measures such as reducing energy or water consumption (52.2%). These activities represent incremental forms of circular engagement that can often be implemented without major organizational restructuring. In contrast, more systemic and coordination-intensive practices are less common. For example, only 35.0% of firms reported reusing materials or components, 26.7% reported incorporating eco-design principles into products or services, and just 21.7% reported collaboration with other firms through industrial symbiosis or similar arrangements. Notably, 15.0% of respondents indicated that they had not implemented any CE practices. These patterns are consistent with findings in the CE literature showing that MSMEs tend to prioritize incremental, efficiency-oriented measures that generate immediate cost savings while avoiding practices requiring significant coordination, technological investment, or institutional support [1,18]. Urban Studies scholars further emphasize that collaborative practices such as industrial symbiosis depend heavily on enabling governance frameworks, shared infrastructure, and spatial proximity among firms, conditions that are often unevenly developed within metropolitan regions [10,24].

To explore whether awareness and perceptions vary across firm characteristics, chi-square tests of independence were conducted. The association between CE awareness and firm size was found to be statistically insignificant at the conventional 5% significance level ($\chi^2 = 11.88$, $p = 0.060$), indicating that awareness of circular economy concepts is relatively evenly distributed across micro, small, medium, and large firms. This finding supports arguments in the Urban Studies literature that sustainability discourses increasingly circulate across metropolitan business ecosystems regardless of firm size, even when firms' capacities to implement CE practices remain uneven [8,9]. Awareness, therefore, appears to be a necessary but insufficient condition for circular economy adoption.

In contrast, the analysis revealed a highly significant relationship between perceived relevance of CE and business activity type ($\chi^2 = 54.02$, $p < 0.001$). This result indicates that firms' evaluations of circular economy relevance are strongly influenced by sectoral characteristics. Manufacturing and real estate firms, which are typically associated with higher material intensity and regulatory exposure, tend to perceive CE as more relevant to their operations. Conversely, firms operating in services and trade display more heterogeneous perceptions of CE relevance. These findings align with insights from CE and urban political economy research, which emphasize that sectoral characteristics, including resource intensity, regulatory exposure, and capital investment requirements, play a crucial role

in shaping firms' engagement with circular strategies [11,15,16]. From an Urban Studies perspective, such sectoral differentiation underscores the importance of designing place- and sector-sensitive policy instruments rather than relying on uniform CE strategies.

Table 2. Awareness and Perceptions of CE ($n = 180$).

(a) Awareness of the CE Concept				
Response	Frequency (n)	Percentage (%)		
Yes	132	73.3		
No	48	26.7		
Total	180	100.0		
(b) Perceived Relevance of CE				
Relevance Level	Scale Value	Frequency (n)	Percentage (%)	Mean (SD)
Not relevant	1	18	10.0	3.64 (1.18)
Somewhat relevant	2	32	17.8	
Moderately relevant	3	47	26.1	
Relevant	4	41	22.8	
Highly relevant	5	42	23.3	
(c) CE Practices Currently Applied (Multiple Responses Allowed)				
CE Practice	Frequency (n)		Percentage (% of firms)	
Recycling waste materials	101		56.1	
Resource efficiency (energy/water reduction)	94		52.2	
Reuse of materials/components	63		35.0	
Eco-design of products/services	48		26.7	
Collaboration with other firms (industrial symbiosis)	39		21.7	
None	27		15.0	
(d) Chi-Square Test				
Variables	χ^2	df	p-value	Interpretation
CE awareness $\times$ firm size	11.88	6	0.060 *	Marginal/not significant
CE Relevance $\times$ business activity	54.02	20	<0.001 **	Highly significant

Significance: $p < 0.01$ ** and $p < 0.10$ *.

Overall, the findings presented in this subsection highlight a clear distinction between the diffusion of circular economy discourse and the practical implementation of CE practices within metropolitan economies. While awareness of CE concepts is widespread across firms, actual engagement remains concentrated in incremental, efficiency-oriented activities that align with immediate economic benefits. More transformative or collaborative forms of circularity remain limited. These patterns reinforce critical perspectives within Urban Studies that caution against assuming that awareness and positive attitudes toward sustainability will automatically translate into structural transformation [7,21]. Instead, effective CE transitions in arid metropolitan regions require governance frameworks, institutional support mechanisms, and spatially embedded policy strategies capable of addressing sectoral differences and firm-level capacity constraints.

4.3. Barriers and Challenges to CE Adoption

This subsection examines the barriers that constrain circular economy (CE) adoption among private sector firms and MSMEs. Rather than treating these barriers as isolated firm-level limitations, the analysis interprets them as outcomes shaped by institutional arrangements, market structures, and metropolitan governance conditions. From an Urban Studies perspective, sustainability transitions are mediated by broader political-economic environments in which firms operate, including regulatory frameworks, labor markets,

and infrastructure systems [8,10,38–40]. Understanding these structural constraints is therefore essential for explaining why CE practices remain unevenly adopted within metropolitan economies.

Respondents were asked to evaluate six commonly identified barriers to CE adoption using a five-point Likert scale (1 = not a barrier; 5 = major barrier). As presented in Table 3, firms generally perceive CE barriers as moderate to significant. External and systemic constraints appear particularly salient. Weak regulatory enforcement emerged as the most significant barrier ($M = 3.66$, $SD = 1.19$), followed closely by market demand uncertainty ($M = 3.53$, $SD = 1.21$). These findings indicate that firms perceive the broader institutional and market environment as a critical determinant of circular transition. Such perceptions align with Urban Studies scholarship that emphasizes CE implementation as a governance-mediated process dependent on regulatory credibility, policy coordination, and demand-side incentives rather than awareness alone [7,21,50].

Operational capacity constraints also feature prominently among perceived barriers. Lack of a skilled workforce ($M = 3.42$, $SD = 1.13$) and limited access to technology ($M = 3.09$, $SD = 1.16$) were rated as important impediments to CE adoption. These findings reflect the challenges MSMEs face in acquiring technical capabilities and implementing new production practices. In contrast, lack of financial resources ($M = 2.87$, $SD = 1.48$) was perceived as the least severe barrier on average, although it still falls within the moderate constraint category. This ordering challenges policy narratives that treat financial support as the primary mechanism for enabling CE adoption and instead highlights the importance of skills development, technological access, and regulatory clarity [11,22,33,41].

To identify the underlying structure of these perceived barriers, an exploratory factor analysis (EFA) was conducted on the six barrier variables. Sampling adequacy and factorability were confirmed using the Kaiser–Meyer–Olkin (KMO) measure and Bartlett’s test of sphericity, following established methodological standards [48,49]. Principal component analysis with varimax rotation produced a three-factor solution with eigenvalues greater than one, jointly explaining 72.9% of the total variance. The rotated factor structure reveals three interpretable dimensions of CE barriers: operational and capability constraints (skills and technology), governance and market environment constraints (regulatory enforcement and demand uncertainty), and knowledge and financial constraints (awareness and financial resources). This multidimensional structure supports Urban Studies arguments that barriers to sustainability transitions arise from the interaction between internal organizational capacities and external institutional conditions [10,26,38–40].

Internal consistency of the extracted factors was assessed using Cronbach’s alpha. Reliability values indicate acceptable internal consistency for the operational–capability factor ($\alpha = 0.683$) and moderate reliability for the governance–market factor ($\alpha = 0.600$). The knowledge–financial factor exhibits lower internal consistency ($\alpha = 0.379$). The relatively low reliability score for the knowledge–financial barrier dimension reflects the heterogeneous nature of constraints faced by MSMEs and should therefore be interpreted as an exploratory grouping of related challenges rather than a unified latent construct.

To examine how these barrier dimensions influence CE adoption behavior, factor scores were generated and regressed against a CE adoption index (ranging from 0 to 5), constructed from firms’ reported circular practices. The results indicate that operational and capability constraints exert a statistically significant negative effect on overall CE adoption ($B = -0.200$, $p = 0.006$). In contrast, governance–market constraints and knowledge–financial constraints do not show statistically significant associations with the adoption index in the aggregate model. These results suggest that while firms perceive institutional and market conditions as major barriers, actual adoption behavior is more directly constrained by internal organizational capabilities such as skills and access to tech-

nology. The manuscript now clarifies that the regression model is exploratory, and that CE adoption behavior is influenced by broader institutional and market factors beyond those included in the model. This interpretation aligns with Urban Studies research highlighting the gap between perceived external constraints and operational realities faced by firms during sustainability transitions [7,31,32,38].

Table 3. Barriers and Challenges to CE Adoption ($n = 180$).

(a) Barriers to CE Adoption						
Barrier	Mean	SD	Median	Interpretation		
Lack of financial resources	2.87	1.48	3	Moderate barrier		
Lack of awareness/knowledge	3.21	1.17	3	Moderate barrier		
Lack of skilled workforce	3.42	1.13	3	Moderate–significant barrier		
Limited access to technology	3.09	1.16	3	Moderate barrier		
Weak regulatory enforcement	3.66	1.19	4	Significant barrier		
Market demand uncertainty	3.53	1.21	4	Significant barrier		
(b) Eigenvalues and Variance Explained						
Factor	Eigenvalue	% of Variance	Cumulative %			
Factor 1	1.98	33.0	33.0			
Factor 2	1.39	23.2	56.2			
Factor 3	1.00	16.7	72.9			
(c) Rotated Factor Loadings (Varimax Rotation)						
Barrier Item	Factor 1		Factor 2	Factor 3		
Lack of skilled workforce	0.64		0.03	0.20		
Limited access to technology	0.76		0.03	0.13		
Weak regulatory enforcement	0.01		0.65	0.07		
Market demand uncertainty	0.02		0.66	0.14		
Lack of awareness/knowledge	0.06		0.32	0.61		
Lack of financial resources	0.01		0.19	0.74		
(d) Reliability of Barrier Factors (Cronbach's α)						
Factor	Items		Cronbach's α			
Operational & capability constraints	Skills, technology		0.683			
Governance & market constraints	Regulation, market		0.600			
Knowledge & financial constraints	Awareness, finance		0.379			
(e) OLS Regression: CE Adoption Index on Barrier Factor Scores						
Predictor	B		p-value			
Operational & capability constraints	−0.200		0.006			
Governance & market constraints	0.042		0.541			
Knowledge & financial constraints	−0.065		0.403			
Note: $N = 171$; $R^2 = 0.058$; Model $p = 0.018$.						
(f) Logistic Regression Results: CE Practices on Barrier Factor Scores (Odds Ratios)						
Practice	OR (F1)	p	OR (F2)	p	OR (F3)	p
Recycling	1.23	0.22	0.90	0.53	0.70	0.056
Resource efficiency	0.74	0.032	1.00	0.98	1.55	0.004
Reuse	0.80	0.12	1.19	0.20	0.78	0.10
Eco-design	0.62	0.001	1.11	0.42	1.13	0.40
Collaboration	0.98	0.90	0.99	0.95	0.71	0.019

To further explore differences across specific CE practices, binary logistic regression models were estimated for individual practices including recycling, resource efficiency, reuse, eco-design, and inter-firm collaboration. The results reveal practice-specific sensitivities to different barrier dimensions. Operational and capability constraints significantly reduce the likelihood of adopting eco-design and resource-efficiency practices, indicat-

ing that technical capacity and workforce skills play a critical role in implementing more advanced circular activities. Knowledge–financial constraints are particularly restrictive for inter-firm collaboration practices, including industrial symbiosis arrangements. This finding is consistent with Urban Studies research emphasizing that collaborative circular practices depend not only on financial resources but also on knowledge-sharing networks, institutional trust, and spatial coordination among firms [10,24].

Overall, the results demonstrate that barriers to CE adoption among metropolitan MSMEs are structural, multidimensional, and practice-specific. While firms frequently emphasize governance uncertainty and market conditions in their perceptions of barriers, internal operational capacities, particularly workforce skills and technological capabilities, emerge as the most decisive constraints on actual adoption behavior. This divergence reinforces critical perspectives in the CE literature that caution against awareness- or regulation-centric approaches and instead call for integrated policy frameworks addressing labor markets, technological capacity, and institutional coordination [11,17,21]. These findings provide an empirical foundation for the subsequent analysis of policy enablers and institutional mechanisms, highlighting where targeted interventions can most effectively support circular economy transitions in arid metropolitan regions.

4.4. Opportunities and Support for Advancing the Circular Economy

This subsection examines the opportunities that MSMEs identify within the circular economy (CE) and the forms of institutional and policy support required to transform these opportunities into tangible investment and implementation. Consistent with Urban Studies scholarship, opportunities are not interpreted as abstract market possibilities but as place-specific development trajectories shaped by metropolitan industrial structures, spatial organization, and governance arrangements [8,9]. Within metropolitan economies, CE opportunities often emerge where material flows, infrastructure systems, and economic specialization intersect. Consequently, identifying how firms perceive opportunities provides insight into how circular transitions may unfold within specific urban–regional contexts.

The survey results indicate that MSMEs recognize a broad range of CE opportunities, although these opportunities are concentrated primarily in resource-based and efficiency-oriented activities. As presented in Table 4, the most frequently identified opportunity areas include waste recycling and materials recovery (65.6%), renewable energy and energy efficiency (57.8%), and green construction and retrofitting (53.3%). These sectors correspond closely to dominant material flows and growth sectors in arid metropolitan regions. Rapid urban expansion, infrastructure development, and high resource consumption generate significant waste streams and energy demand, creating immediate entry points for circular practices. Urban Studies research has consistently shown that CE initiatives often first emerge in sectors where material throughput and environmental pressures are most visible, allowing firms to adopt circular practices that align with both regulatory priorities and cost-reduction incentives [10,24].

Moderate levels of opportunity recognition are observed for repair, refurbishment, and reuse services (41.1%) as well as sustainable packaging and eco-design activities (38.3%). These sectors represent more labor-intensive and innovation-oriented pathways within the circular economy. Their development depends not only on firm-level initiative but also on supportive market demand, consumer awareness, and regulatory frameworks that promote product longevity and sustainable design standards. Such activities are particularly relevant for metropolitan economies because they can generate local employment and strengthen urban service ecosystems. However, their expansion typically requires complementary policy instruments and capacity-building programs that enable MSMEs to develop the necessary technical and organizational capabilities.

Table 4. MSMEs Opportunities and Support for Advancing CE ($n = 180$).

(a) Perceived CE Opportunities for MSMEs (Multiple Responses Allowed)			
Opportunity Area	(<i>n</i>)	(%)	Urban Studies Interpretation
Waste recycling & materials recovery	118	65.6	Immediate, resource-based opportunity linked to existing waste streams
Renewable energy & energy efficiency	104	57.8	Cost-saving and policy-aligned
Green construction & retrofitting	96	53.3	Closely linked to urban growth and infrastructure expansion
Repair, refurbishment & reuse services	74	41.1	Skills- and labor-intensive
Sustainable packaging & eco-design	69	38.3	Market-dependent
Organic waste valorization	61	33.9	Infrastructure-dependent
Circular supply-chain & logistics	49	27.2	Coordination-intensive
Digital sharing/product-as-a-service	42	23.3	Platform- and governance-dependent
Sustainable tourism/blue-green niches	36	20.0	Spatially specific
(b) Importance of Support Mechanisms for CE Adoption			
Support Mechanism	Mean	SD	Urban Studies Interpretation
Financial incentives (grants, loans, green finance)	4.32	0.79	Reduces investment risk and lowers entry barriers
Training & capacity building	4.21	0.83	Addresses skills gaps and supports organizational learning
Government regulation & enforcement	4.05	0.88	Signals policy credibility and reduces uncertainty
Partnerships with large firms/anchor industries	3.94	0.91	Enables value-chain integration and knowledge spillovers
Access to recycling facilities & eco-parks	3.87	0.95	Provides shared spatial infrastructure
(c) Willingness to Invest in CE Practices with Adequate Support			
Response	(<i>n</i>)	(%)	Urban Studies Interpretation
Yes	92	51.1	Strong latent demand for CE investment
Maybe/conditional	63	35.0	Willingness contingent on incentives and policy design
No	25	13.9	Persistent structural or sector-specific constraints

In contrast, opportunities associated with systemic and coordination-intensive circular models are identified less frequently. Circular supply chains and logistics (27.2%) as well as digital sharing or product-as-a-service platforms (23.3%) are recognized by a smaller share of firms. These activities require higher levels of inter-firm coordination, digital infrastructure, and data integration than most MSMEs can independently provide. Urban Studies literature emphasizes that such advanced circular strategies depend on metropolitan-scale coordination and institutional capacity, including logistics networks, data-sharing systems, and collaborative governance arrangements [10,24]. Without these enabling structures, MSMEs often remain confined to incremental forms of circularity rather than participating in more transformative system-wide transitions.

Similarly, sustainable tourism and blue-green economy niches (20.0%) are identified by a relatively small proportion of respondents. This reflects the spatial specificity of certain circular opportunities, which depend on localized environmental assets and place-based development strategies [61]. In coastal and resource-sensitive metropolitan regions, such activities can support broader sustainability objectives by linking ecological conservation with economic diversification [56,61,62]. However, their development requires targeted planning frameworks and coordinated urban–regional development policies that integrate tourism, environmental management, and circular resource use.

While MSMEs clearly recognize a variety of CE opportunities, their ability to realize these opportunities depends strongly on access to institutional and policy support mecha-

nisms. Respondents evaluated five types of support on a five-point Likert scale, and all were rated as important to very important, indicating a clear expectation of coordinated public and institutional intervention. As shown in the analysis, financial incentives, including grants, concessional loans, and green financing instruments, received the highest mean rating ($M = 4.32$, $SD = 0.79$). This reflects the importance of reducing investment risk and improving access to capital for firms considering circular investments. Financial support is particularly important for MSMEs, which often operate with limited internal resources and face difficulties accessing conventional financing channels [8,19].

Training and capacity-building initiatives also receive strong support ($M = 4.21$, $SD = 0.83$), reinforcing findings from Section 4.3 that workforce skills and technical capabilities represent critical constraints on CE adoption. Programs aimed at enhancing technical knowledge, managerial capacity, and sustainability-oriented business models can therefore play an important role in enabling MSMEs to engage more effectively with circular practices. In addition, government regulation and enforcement ($M = 4.05$, $SD = 0.88$) are rated as highly important, signaling the significance of policy credibility and regulatory consistency. Urban Studies research frequently highlights that sustainability transitions depend not only on incentives but also on stable regulatory frameworks that reduce uncertainty and guide long-term investment decisions [7,21].

Support mechanisms related to inter-firm collaboration and spatial infrastructure are also recognized as important. Partnerships with large firms or anchor industries ($M = 3.94$, $SD = 0.91$) can facilitate value-chain integration and knowledge spillovers, allowing MSMEs to participate in broader circular production networks. Similarly, access to recycling facilities and eco-parks ($M = 3.87$, $SD = 0.95$) provides shared metropolitan infrastructure that enables smaller firms to overcome scale limitations associated with waste processing and resource recovery. These findings highlight the relational and spatial dimensions of CE implementation, emphasizing the importance of coordinated metropolitan planning and industrial symbiosis initiatives [8–10].

The interaction between opportunity recognition and institutional support is further reflected in firms' willingness to invest in circular practices. As shown in the analysis, more than half of respondents (51.1%) express a clear willingness to invest in CE initiatives if adequate financial or technical support is available. An additional 35.0% report conditional willingness, indicating that their investment decisions depend on policy design, incentive structures, and market conditions. Only 13.9% of firms report unwillingness to invest in CE practices. This distribution suggests the presence of substantial latent demand for circular investments among MSMEs, provided that appropriate enabling conditions are established. From an Urban Studies perspective, these findings support the argument that MSMEs should not be viewed as passive or resistant actors within sustainability transitions. Instead, they represent conditionally willing system participants whose engagement depends on governance frameworks, institutional capacity, and risk-sharing mechanisms [7].

Taken together, the results of this subsection demonstrate a strong alignment between recognized CE opportunities, demand for institutional support, and latent willingness to invest among metropolitan MSMEs. Firms clearly identify viable entry points into the circular economy, particularly in waste management, energy efficiency, and construction-related activities, but emphasize that scaling these opportunities requires coordinated policy interventions, skills development programs, regulatory clarity, and access to shared metropolitan infrastructure. From an Urban Studies perspective, these findings reinforce the argument that circular economy transitions in arid metropolitan regions are governance-mediated urban development processes rather than spontaneous market outcomes. Effective CE strategies must therefore combine economic incentives, institutional coordination, and

spatial planning mechanisms to mobilize MSMEs as active participants in circular urban transformation [8,10,11,17].

4.5. Future Outlook: The Strategic Role of MSMEs in Advancing the Circular Economy

This subsection explores respondents' perspectives on the future role of MSMEs in advancing the circular economy (CE) within the metropolitan context. Consistent with Urban Studies scholarship, future outlook is interpreted not simply as a set of aspirations but as an expression of anticipated development pathways shaped by metropolitan governance structures, institutional expectations, and evolving economic opportunities [6–9]. Firms' perceptions of future roles therefore provide insight into how CE transitions may unfold within metropolitan economies and how different actors expect to position themselves within emerging circular systems.

The survey results reveal a forward-looking and strategically differentiated vision of MSME engagement in the circular economy. Rather than viewing MSMEs solely as adopters of incremental efficiency practices, respondents anticipate that these firms will assume multiple roles as implementers, integrators, and innovators within metropolitan circular systems. As shown in Table 5, the most frequently identified future role for MSMEs is recycling and waste management (71.3%), reflecting strong expectations that smaller firms will continue to anchor localized waste-to-resource solutions. Urban Studies research has repeatedly emphasized the importance of decentralized material recovery systems in metropolitan regions, where localized waste streams can support small-scale recycling, repair, and resource recovery activities [1,10,11,23]. In this sense, MSMEs are perceived as critical operational actors capable of maintaining the everyday functioning of circular material flows.

Table 5. Future Roles of MSMEs in Advancing CE (Multiple Responses Allowed; $n = 180$).

Future Role of MSMEs	(n)	(%)	Urban Studies Interpretation
Recycling and waste management	129	71.3	Anchors localized circular material flows
Supply chain integration with large firms	124	68.5	Enables metropolitan-scale value-chain coordination
Community engagement and awareness	98	54.1	Links CE transition to everyday consumption practices
Resource efficiency in production	90	49.7	Supports incremental but scalable environmental gains
Innovation and eco-friendly product design	83	45.9	Drives bottom-up circular innovation
Green job creation	82	45.3	Connects CE to inclusive urban employment

A similarly high proportion of respondents emphasize supply-chain integration with large firms (68.5%) as a key future role. These finding highlights expectations that MSMEs will function as connective nodes within metropolitan production networks, linking local firms with larger industrial actors, logistics hubs, and regional value chains. Such integration is particularly important in industrial metropolitan regions, where anchor firms and large-scale industrial clusters generate material flows that smaller firms can process, reuse, or redistribute. The prominence of this role reinforces earlier findings presented in Sections 4.3 and 4.4, which indicate that collaboration, institutional linkages, and shared infrastructure are essential for scaling CE practices beyond isolated firm-level initiatives [8,11,17].

More than half of respondents identify community engagement and awareness-building (54.1%) as an important future role for MSMEs. This finding reflects recognition that smaller firms are deeply embedded in local communities and therefore occupy a strategic position for influencing consumption behavior, environmental awareness, and social norms related to resource use. Urban Studies scholars increasingly highlight this social dimension of CE transitions, arguing that sustainability transformations require engagement

with everyday practices, local social relations, and community-level behavioral change rather than focusing solely on production systems or technological innovation [7,21,33].

Other anticipated roles include improving resource efficiency in production (49.7%), fostering innovation and eco-friendly product design (45.9%), and contributing to green job creation (45.3%). These findings indicate that respondents expect MSMEs to contribute simultaneously to technological innovation, environmental performance, and inclusive employment. In metropolitan contexts, such contributions can strengthen the resilience of local economies by promoting sustainable production practices while generating new employment opportunities in recycling, repair services, eco-design, and related sectors. From an Urban Studies perspective, this multifunctional role highlights the potential for MSMEs to act as locally embedded drivers of sustainability transitions, linking environmental objectives with urban economic development.

Overall, the future outlook articulated by respondents positions MSMEs as multifunctional actors within metropolitan circular systems, simultaneously serving as innovators, service providers, community intermediaries, and supply-chain partners. The prominence of recycling and supply-chain integration roles suggests that respondents envision a circular economy characterized by stronger institutional coordination and networked production systems rather than isolated firm-level initiatives. From an Urban Studies perspective, these findings reinforce arguments that successful CE transitions depend on hybrid governance arrangements, where MSMEs operate within coordinated metropolitan systems shaped by policy frameworks, spatial planning, and industrial strategy [8,10].

The emphasis on community engagement and green job creation further highlights the expectation that circular economy strategies should generate broader social and economic benefits alongside environmental improvements. Such outcomes align with emerging Urban Studies debates that frame CE transitions not only as environmental initiatives but also as opportunities for inclusive urban development and local economic diversification. In rapidly growing metropolitan regions, MSMEs can therefore play a crucial intermediary role by connecting industrial actors, local communities, and public institutions within integrated sustainability frameworks.

Taken together, the results suggest that the future trajectory of the circular economy in arid metropolitan regions will depend heavily on empowering MSMEs as strategic intermediaries within emerging circular systems. By linking large industrial actors, local communities, and public institutions, MSMEs have the potential to translate circular economy policies into locally embedded practices. These insights provide an important empirical foundation for the subsequent discussion of policy implications and strategic pathways presented in Section 5, where the evolving role of MSMEs in metropolitan circular transitions is examined in greater conceptual and policy-oriented depth.

The empirical findings presented across Sections 4.1–4.5 reveal a consistent pattern: MSMEs demonstrate substantial awareness of circular economy principles, recognize multiple sectoral opportunities, and express strong willingness to engage in CE practices when supportive institutional conditions are present. However, their participation remains shaped by multidimensional barriers related to skills, technology access, regulatory clarity, and market coordination. These results suggest that MSMEs should not be viewed merely as passive adopters of sustainability practices but rather as conditionally willing system-building actors whose role evolves as governance frameworks, industrial networks, and institutional capacities develop. To synthesize these empirical insights, the following section introduces a conceptual interpretation of MSMEs' evolving role across different stages of the circular economy transition in arid metropolitan regions (Figure 2). This framework integrates firm-level behavior with metropolitan governance dynamics and highlights how

MSMEs progressively shift from localized operational actors toward strategic participants in coordinated circular urban systems.

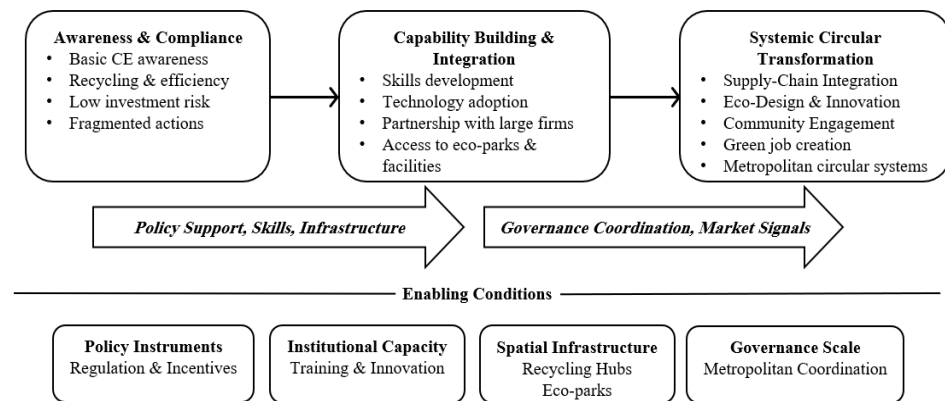


Figure 2. MSMEs' Evolving Role in the CE Transition in Arid Metropolitan Regions. Conceptual framework illustrating the progressive evolution of MSMEs from basic adoption of circular practices toward systemic CE participation. The framework identifies three transition phases, awareness and compliance, capability building and integration, and systemic circular transformation, and highlights the governance, institutional, and spatial conditions that enable movement across these phases in arid metropolitan contexts.

5. Discussion and Policy Implications

The empirical findings of this study contribute to a growing body of circular economy (CE) research by providing evidence from an arid metropolitan context while also refining existing debates on the role of MSMEs in sustainability transitions. Earlier CE studies, particularly those focused on European and East Asian metropolitan regions, have consistently shown that small firms tend to adopt incremental circular practices such as recycling, waste reduction, and energy efficiency while rarely engaging in systemic circular models such as industrial symbiosis or platform-based sharing systems [1,18,32]. The results of the present study confirm these patterns but also extend them in two important ways. First, the findings demonstrate that relatively high awareness of CE among firms does not automatically translate into deeper adoption, challenging earlier interpretations that framed informational gaps as the primary barrier to circular transitions [2,3]. Instead, the analysis reveals that capability-related constraints, especially workforce skills, access to technology, and institutional coordination, play a more decisive role in shaping firm behavior. Second, the results show that MSMEs in arid metropolitan regions display a strong conditional willingness to invest in CE practices when adequate policy support and institutional infrastructure are available. These findings align with more recent urban political economy perspectives that conceptualize sustainability transitions as governance-mediated processes shaped by institutional capacity and spatial economic structures rather than purely market-driven adjustments [7,22,34].

Building on these empirical insights, this section interprets the results within broader debates on urban sustainability transitions, metropolitan governance, and the evolving role of small firms in structural economic transformation. Rather than framing CE as a purely technical or market-driven shift, the discussion emphasizes the institutional, spatial, and political-economic conditions that shape MSMEs' engagement with circular practices in arid metropolitan regions. Figure 2 provides an integrative conceptual synthesis of these findings. Specifically, Figure 2 illustrates the evolving role of MSMEs across different phases of the circular economy transition, showing how firms move from basic awareness and compliance toward capability development, value-chain integration, and systemic circular transformation. The framework visually connects the empirical evidence on barriers,

opportunities, and support mechanisms identified in Sections 4.2–4.4, while highlighting the cross-cutting importance of governance capacity, policy support, skills development, and metropolitan-scale infrastructure in enabling this progression.

Consistent with earlier empirical research, the findings confirm that MSMEs tend to prioritize resource-based and efficiency-oriented circular practices, including recycling, energy efficiency, and green construction. Similar adoption patterns have been documented in European and Asian metropolitan economies, where smaller firms typically adopt circular activities that align with existing operational routines and deliver immediate economic returns [1,18,32]. As illustrated in the first phase of Figure 2, these practices correspond to a stage of incremental circularity characterized by relatively low-risk adaptation rather than systemic transformation. However, the present study extends this literature by demonstrating that such adoption patterns are less a consequence of limited awareness and more the result of capability-related constraints, particularly workforce skills and technological capacity. This finding reinforces recent urban studies research emphasizing that sustainability transitions are often constrained by institutional and infrastructural limitations rather than by informational deficits alone [22,34].

The limited uptake of more advanced circular models, such as circular supply chains, industrial symbiosis, and digital platform-based services, also reflects patterns observed in previous studies of metropolitan CE transitions [10,24]. These models require coordination among multiple actors, access to shared infrastructure, and integration within broader value chains. The present findings add nuance to this literature by showing that MSMEs recognize these models as viable future opportunities but perceive them as difficult to implement under current institutional conditions. As depicted in Figure 2, this situation represents a latent transition potential, in which firms possess both awareness and interest but lack the enabling governance structures required to translate these intentions into systemic circular practices.

Importantly, the strong conditional willingness to invest identified in this study challenges earlier portrayals of MSMEs as inherently risk-averse or reluctant participants in sustainability transitions [16]. Instead, the results support more recent scholarship suggesting that MSMEs are conditionally willing actors whose engagement depends on policy credibility, risk-sharing mechanisms, and access to enabling infrastructure [7,24]. Within the conceptual framework presented in Figure 2, these enabling conditions function as cross-cutting institutional layers that support firms' progression from initial adoption toward deeper participation in metropolitan circular systems.

From a regional perspective, the results complement existing research on arid and Gulf metropolitan contexts, where CE policies have largely been driven by state-led initiatives targeting large industrial actors and flagship infrastructure projects [13,14,27]. While such strategies provide important strategic direction, the present findings highlight a persistent gap between macro-level policy ambitions and the operational realities faced by smaller firms. By foregrounding the experiences of MSMEs, this study responds to calls for more grounded analyses of CE implementation that account for the diverse actors embedded within metropolitan economic systems [20–22].

The comparative insights derived from the empirical results suggest several policy implications for advancing circular economy transitions in arid metropolitan regions.

- First, CE strategies should shift from awareness-oriented interventions toward sustained capability-building initiatives. As illustrated in the transition from Phase 1 to Phase 2 in Figure 2, targeted training programs, technical assistance, and support for technology adoption are essential for enabling MSMEs to move beyond incremental efficiency measures toward more integrated circular practices.

- Second, policy credibility and regulatory coherence play a central role in shaping MSME engagement. Stable, predictable, and enforceable regulatory frameworks reduce uncertainty and encourage firms to invest in circular innovations. Conversely, fragmented or short-term policy signals risk reinforcing incremental adaptation rather than enabling systemic transformation.
- Third, the findings underscore the importance of metropolitan-scale infrastructure and institutional coordination. Investments in shared facilities such as eco-parks, recycling hubs, and circular logistics platforms can significantly lower entry barriers for MSMEs and facilitate inter-firm collaboration. Such infrastructure is particularly important in arid metropolitan regions where resource constraints intensify the need for coordinated resource management [10,11,17,38–41].
- Fourth, CE policies should reposition MSMEs as integrators within circular value chains rather than as peripheral beneficiaries of financial incentives. Partnerships between MSMEs and large firms can enhance knowledge transfer, enable industrial symbiosis, and embed smaller firms within metropolitan circular production networks. These partnerships correspond to the third transition phase illustrated in Figure 2, where firms participate in systemic circular transformation.
- Finally, the emphasis placed by respondents on community engagement and green job creation highlights the importance of aligning CE strategies with broader urban development objectives. Urban Studies scholarship increasingly stresses that circular economy initiatives must address social inclusion and employment outcomes in order to maintain political legitimacy and public support [22,34]. Integrating CE policies with local economic development strategies can therefore strengthen both environmental sustainability and social resilience.

By linking firm-level behavior with metropolitan governance structures, institutional capacity, and spatial infrastructure, this study contributes to Urban Studies scholarship on sustainability transitions. The conceptual framework presented in Figure 2 advances existing CE models by situating MSMEs within a dynamic, place-based transition pathway rather than treating them as passive adopters of predefined practices. Overall, the findings demonstrate that advancing the circular economy in arid metropolitan regions requires empowering MSMEs as system-building actors capable of linking production systems, policy frameworks, and community dynamics within coordinated urban governance arrangements. In doing so, the study contributes both empirically and conceptually to ongoing debates on inclusive, place-sensitive circular economy transitions.

6. Conclusions

This study investigated the role of the private sector and micro, small, and medium-sized enterprises (MSMEs) in advancing the circular economy (CE) within an arid metropolitan context, using the Dammam Metropolitan Area as an empirical case. Adopting a place-based and governance-sensitive Urban Studies perspective, the research contributes to ongoing debates on sustainability transitions by demonstrating that MSMEs should not be understood merely as passive adopters of circular practices. Instead, they emerge as conditionally willing and structurally embedded actors whose engagement with CE is shaped by operational capacity, sectoral positioning, and the institutional and spatial configuration of metropolitan governance systems.

Empirically, the findings show that MSMEs predominantly adopt resource-based and efficiency-oriented circular practices such as recycling, energy efficiency, and green construction, while more systemic models, including industrial symbiosis and circular supply-chain integration, remain limited. These patterns reflect rational adaptation to prevailing governance and market conditions rather than deficiencies in awareness or moti-

vation. The analysis further demonstrates that capability-related constraints, particularly workforce skills and access to technology, exert a stronger influence on CE adoption than awareness alone. At the same time, the strong conditional willingness among firms to invest in circular practices indicates substantial latent transition potential when appropriate institutional support is provided.

The study therefore contributes conceptually by reframing CE transitions as governance-mediated urban development processes embedded within metropolitan political economies. It highlights that advancing circular transitions in arid metropolitan regions requires coordinated policy mixes integrating regulatory credibility, financial incentives, skills development, shared infrastructure, and inter-firm collaboration. Within such frameworks, MSMEs can function as system-building actors, linking production networks, policy frameworks, and local communities within emerging circular urban systems.

Several limitations should be acknowledged. The cross-sectional design captures MSME perceptions and practices at a single point in time and therefore cannot assess the dynamic evolution of CE adoption. In addition, reliance on self-reported survey data may introduce response bias associated with socially desirable sustainability practices. The study also focuses on one metropolitan case and does not explicitly capture informal economic activities that may play a role in circular practices in some contexts.

Future research can address these limitations through longitudinal studies tracking how MSME engagement evolves over time, comparative analyses across multiple arid metropolitan regions, and mixed-method approaches combining survey data with qualitative interviews, policy analysis, and spatial investigation. Such approaches would deepen understanding of how governance structures, industrial networks, and everyday economic practices interact to shape circular economy transitions. Further research should also examine the social implications of CE transitions, including employment quality, distributive outcomes, and community well-being.

Overall, the findings suggest that advancing the circular economy in arid metropolitan regions requires moving beyond awareness-based strategies and isolated financial incentives toward integrated, place-sensitive governance frameworks that actively empower MSMEs. When supported by coherent regulatory environments, targeted capability-building programs, and access to shared metropolitan infrastructure, MSMEs can function as strategic intermediaries within emerging circular systems, linking production networks, policy frameworks, and local communities. By foregrounding the institutional, spatial, and political-economic conditions shaping MSME engagement, this study demonstrates that circular economy transitions in arid metropolitan regions should be understood as urban governance processes rather than purely technological or market-driven shifts. In this sense, empowering MSMEs as system-building actors is not only a practical policy priority but also a critical pathway for achieving inclusive, resilient, and place-sensitive circular urban development.

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