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The transition to a circular economy: different paths for international and non-international micro-manufacturing firms

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Abstract
This article examines how environmental awareness, stakeholder pressure, circular economy orientation and internal barriers influence circular economy practices in international and non-international micro-firms. For this, we utilised fuzzy set qualitative comparative analysis (fsQCA) using data from 128 micro firms operating in different manufacturing industries in Estonia. Three paths were identified for explaining circular economy practices in internationally operating micro-firms and two paths for explaining it in micro-firms that do not operate internationally. Our results show that understanding the impact of the four before-mentioned aspects can be beneficial for engaging in circular economy efforts in both international and non-international micro-firms. The intricate five pathways (three for international and two for non-international) through which environmental awareness, stakeholder pressure, circular economy orientation, and internal barriers shape circular economy practices in micro-firms, challenging conventional understandings and offering nuanced insights for effective engagement in sustainable business practices. Based on the findings, theoretical and practical implications of this study and directions for future research are discussed.

Keywords Circular economy · Transition · Micro-firms · Environmental awareness · Stakeholder pressure · Circular economy orientation · Internal barriers · Circular economy practices

1 Introduction

The transition to a circular economy (CE) is urgently needed [1]. CE has been described as an economic model that seeks to decouple economic growth from resource consumption and environmental degradation by promoting the continuous flow and regeneration of materials and resources within the system [2]. This study focuses on CE practices that involve the transition from the traditional linear model of manufacture, use and disposal to a more sustainable production approach based on the reuse, remanufacturing and recycling of resources [3, 4]. These practices aim to enhance the overall sustainability of companies and societies [5]. The transition is associated with major investments as well as organisational changes [6]. At the same time, companies are exposed to a number of simultaneous crises that make this transition considerably more difficult [7]. Smaller companies in particular find it difficult to tackle and implement significant changes [2]. This is especially true for micro-enterprises, which make up the majority of businesses in all economies [8]. Despite

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the abundance of existing studies on the adoption of CE practices in smaller enterprises [9–13], there appears to be a lack of studies examining the role of various internal and external factors on the readiness and implementation of CE practices in micro-enterprises (with fewer than 10 full-time employees and an annual turnover or balance sheet total of less than EUR 2 million). This applies to both nationally and internationally operating micro-enterprises. Investigating the differences between international and non-international micro-enterprises in the adoption of CE practices appears relevant for a variety of reasons. (I) International activities (such as exporting different types of products) expose companies to different regulatory frameworks and market requirements, which can encourage the adoption of CE practices such as waste treatment, reduction and recycling, thereby improving the brand reputation and financial performance of the companies concerned [14, 15]. (II) The need to comply with international regulations increases the pressure on companies to adopt environmentally innovative practices, such as life cycle assessment (LCA) or eco-design [16, 17]. (III) Internationally operating companies can also benefit from access to external knowledge networks, which can be crucial in the implementation of CE practices, including process redesign and technological innovation [18]. Investigating the differences between international and non-international micro-enterprises regarding the introduction of CE practices is therefore seen as relevant to accelerate the transition to CE. Additionally, the execution of country-specific studies is crucial because the adoption of CE practices is influenced by contextual factors, such as government policies, economic conditions, cultural norms, the impact of stakeholders, or the levels of environmental awareness and organizational readiness which can differ considerably from one country to another [19, 22–24]. Hence, identifying and understanding contextual (local) nuances is vital for developing and executing tailored measures and programmes dedicated to the adoption of CE practices in micro-enterprises.

Against the background presented, this paper asks the following questions: (i) How do aspects such as environmental awareness, stakeholder pressure, CE orientation, and internal barriers influence CE practices in micro-firms? And (ii) How do they differ between international and non-international micro-firms? Existing research suggests that these four aspects are critical regarding CE adoption. The study is based on a sample of 128 Estonian micro-enterprises operating in different manufacturing sectors. Estonia, as part of Eastern Europe with a catch-up economy [20], faces unique challenges in transitioning to a CE. This transition has been slower compared to Western European countries [21], which makes the country an interesting subject of study and contributes to the diversity of CE studies.

To answer the research questions, we apply a configurational approach (i.e., fsQCA). This technique allows us to specify interactions between a set of interrelated aspects, thus allowing us to better understand how certain organizational aspects affect CE practices in micro-enterprises. fsQCA offers the opportunity to gather a deeper understanding of the relationship between variables to better predict and explain real-world business phenomena [25]. Moreover, we adopt complexity theory as the theoretical lens of the paper as it is well-suited for analysing patterns of interaction among system elements at different levels and times [26]. Thus, this theory seems suitable for this study. A focus on micro-enterprises operating in manufacturing industries is justified by existing research that highlights the distinctions between manufacturing and service industries, including differences in business models and value chain organization [27, 28]. Finally, a distinction between international and non-international micro-enterprises seems to be useful in this context, as research has highlighted the role of internationalisation as a push factor for changes in smaller companies [29, 30].

By unearthing the role of the above-mentioned aspects in conjunction with CE practices in internationally and non-internationally operating micro-firms located in Estonia, this study advances existing research dedicated to sustainable development and strategic management of smaller firms, micro-firms in particular.

The paper is organised as follows. The next section provides the theoretical foundation of the study. The study's methodology is outlined in the third section. The data analysis and results are presented in section four. This is followed by the discussion and the study's implications. The paper terminates with a conclusion that also highlights the study's limitations and directions for further research.

2 Theoretical background

This study delves into the landscape of micro-firms within the manufacturing sector, focusing on five pivotal constructs: CE practices as the primary outcome, and environmental awareness, stakeholder pressure, CE orientation, and internal barriers as key antecedent conditions [31, 32]. This selection is guided by the distinct dynamics of the manufacturing industry, acknowledging variances in business models and value chain organisation compared to service industries [27, 28]. The four selected antecedent conditions influencing CE practices in micro manufacturing firms are chosen for their critical roles in shaping CE practices. Environmental awareness stands out as a fundamental motivator for firms to embrace CE principles, as evidenced by the imperative to reduce waste and emissions, contributing to sustainable production and resource efficiency [33, 34]. Stakeholder pressure, both internal and external, significantly influences firms' decisions to adopt CE practices, with stakeholders such as customers, employees, investors, non-governmental organisations (NGOs), and competitors exerting considerable influence on economic and environmental performance [19, 35]. CE orientation, driven by organizational agility and external pressures, underscores the strategic adoption of circular business models and practices, further emphasizing the importance of aligning business strategies with sustainability goals [36]. Additionally, internal barriers, including technical expertise and communication challenges, pose significant hurdles to CE adoption, highlighting the need to address internal organizational dynamics to facilitate successful transitions towards circularity [37]. By focusing on these factors, we aim to provide a comprehensive understanding of the multifaceted challenges and opportunities micro-manufacturing firms encounter in embracing CE practices, ultimately aiding in the development of targeted interventions and strategies to promote sustainable manufacturing practices and achieve long-term environmental goals. Based on the literature background (2.1–2.5) and taking the theoretical lens of complexity theory, we developed Fig. 1 to illustrate the complex interactions and configurations of the antecedent conditions influencing CE practices in micro-manufacturing firms. This figure highlights how environmental awareness, stakeholder pressure, CE orientation, and internal barriers interact dynamically to shape CE practices, emphasizing the importance of a holistic and configuration-based perspective.

2.1 Circular economy practices in micro-manufacturing firms

The rise of the CE as an alternative to the linear economic model has attracted considerable notice as a strategy for tackling economic, environmental, and social issues [38, 39]. In Europe alone, CE practices are estimated to generate business benefits of 1.8 trillion Euros annually by 2030 [40]. The manufacturing sector, which is heavily dominated by smaller companies, assumes a pivotal role in global economies, necessitating focused attention on CE practices within these organisations [41]. Nevertheless, despite increasing awareness and initiatives, the circularity of the global economy remains limited, with only 8.6% adopting circular practices, and resource recycling rates are generally inadequate [42].

CE implementation requires conducive factors such as favourable regulations, infrastructure, and cost-effective circular practices [2, 43]. The significance of finance, technology investment, and managerial skills becomes apparent in the transformation from linear to circular [44]. In the manufacturing context, micro-manufacturing firms emerge as a critical focus for research on CE practices. Despite their size, these micro-firms collectively contribute significantly to global environmental impacts. In Europe, for instance, micro-firms represent a staggering 93% of all businesses and play a vital role in terms of value added (18.7%) and employment (29.2%) [45]. Moreover, micro-firms contribute substantially to carbon emissions, accounting for 63% of the total carbon emissions from European firms [46]. Recognizing the pervasive influence of micro-firms on environmental sustainability, it becomes imperative to focus on this segment in the study of CE practices.

These entities face unique challenges, including limited financial resources and technical skills, making the transition to CE more intricate [47]. While recent studies addressing CE practices have not exclusively focused on micro-enterprises,

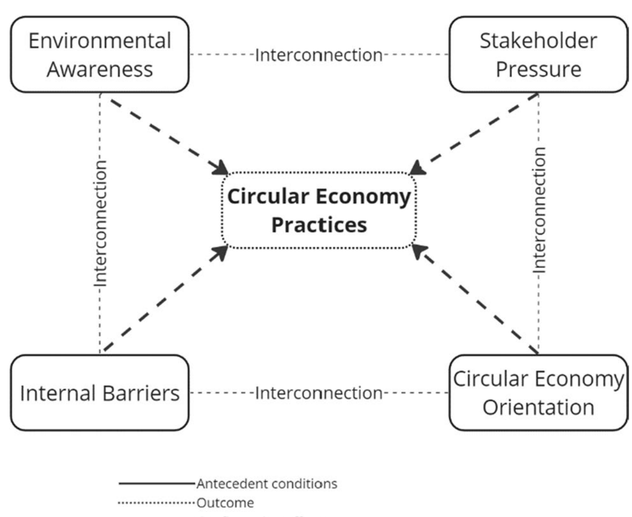

Fig. 1 Research model (compiled by the authors)

it is noteworthy that these investigations have included micro-enterprises as part of their broader samples of micro, small and medium enterprises (MSMEs) e.g., [48–50].

2.2 Environmental awareness

Environmental awareness within enterprises stands as a pivotal construct in the literature on circular economy [51, 52] and is referred to as a firm's concern and comprehension of environmental problems [53]. Increasing environmental awareness is imperative for fostering a consistent understanding among managers and employees on various facets of environmental management, including strategies and policies at different organizational levels (e.g., firm, region, state) [54]. Effectively supporting environmental awareness in a business, particularly in micro-enterprises, necessitates explicit communication of core environmental concerns both internally and externally [55]. These critical environmental concerns encompass issues such as escalating environmental pollution, the accountability of firms for environmental degradation, and the tangible capacities of businesses to embrace circular initiatives aimed at mitigating environmental pollution—such as the principles of reduce, reuse, and recycle [53].

While previous research has extensively explored customers' environmental awareness [56], relatively few empirical investigations have delved into environmental awareness at the firm level. Notably, recent studies have primarily focused on practices that cultivate environmental consciousness among managers [57]. Consequently, empirical research addressing the transformation of environmental awareness through sustainability strategy formulation at the firm level remains scarce [32]. However, the study by Margaret et al. [58] suggests that multinational firms are often subject to international scrutiny and may have higher environmental awareness due to the need to comply with diverse environmental standards and to maintain their global reputation. International small and medium-sized enterprises (SMEs) tend to have higher environmental awareness levels compared to non-international SMEs, as they are more exposed to global sustainability trends and regulations [59]. This heightened awareness in international firms is driven by the necessity to navigate varying environmental regulations across different countries and the pressure to uphold their reputation on a global scale. Exposure to international markets brings international SMEs into contact with progressive environmental policies and practices, which they are often motivated to adopt not only for compliance but also to enhance their competitiveness and brand image. The integration of sustainable practices allows these firms to differentiate themselves in the marketplace, attract eco-conscious consumers, and enter new markets that have stringent environmental requirements. The study by Pronti, Zecca, and Antonioli [8] that micro-firms' strategies are more influenced by the environmental awareness of the owner further underscores the pivotal role of individual consciousness in shaping business approaches. This insight aligns with the proposed idea that environmental awareness is a key determinant in CE practices. Considering the limited empirical research on the transformation of environmental awareness at the firm level, the proposition suggests that this relationship may be more pronounced in international micro firms compared to their non-international counterparts. International micro firms, exposed to diverse environmental regulations and global sustainability trends, are likely to adopt innovative CE practices that exceed mere compliance. Margaret et al. [58] support this by showing that multinational firms develop higher environmental awareness due to international scrutiny. Additionally, Pronti, Zecca, and Antonioli [8] highlight that the strategies of micro-firms are heavily influenced by the environmental consciousness of their owners, underscoring the critical role of individual leadership in driving environmental initiatives within these enterprises. This inference is drawn from the recognized importance of environmental awareness in guiding strategies and policies across organizational levels, particularly in micro-enterprises, where effective communication and understanding of environmental issues are essential for implementing circular initiatives.

Proposition 1 Environmental awareness is more strongly related to circular economy practices in international micro-firms than non-international ones.

2.3 Circular economy orientation

The literature reveals that the exploration of CE orientation at the firm level is still in its early stages, with a limited number of relevant research articles identified [60, 61]. Despite its preliminary status, this construct has gained increasing attention from researchers, indicating its potential to serve as a catalyst for achieving competitive advantage [61, 62].

However, the absence of a definition for circular economy orientation necessitates clarification. Liu and Chang (p.7) [63] introduced the term "closed-loop orientation," which is defined as a reflection of the "strategic orientation toward the recyclability of materials/components/products throughout the entire supply chain loop." This term provides a mechanism that may elucidate the translation of general strategic orientations into CE practices. Goyal et al. [64] offer another definition, for these authors CE orientation means: "involving the focus on setting up end-to-end processes for e-waste collection, sorting, and segregation into reusable metal extracts." Building upon the synthesis of existing literature [61–65], the current study defines CE Orientation as a strategic mindset and operational framework that surpasses mere waste minimization and recycling efforts. Instead, it encompasses comprehensive initiatives, internal comprehension of circular economy practices, and seamless coordination among all stakeholders. This definition aims to foster a holistic approach, embedding circular principles throughout the organizational fabric.

The discourse surrounding circular economy orientation is evolving, emphasizing the necessity for a nuanced comprehension of its multifaceted dimensions. The complexity prompts an examination of how circular economy orientation influences different organizational contexts, particularly in the realm of international micro-firms versus their non-international counterparts. Internationalization is a pivotal factor in this exploration, as it not only exposes firms to diverse market demands and competition, fostering innovation and customer-centric approaches [66], but also shapes their approach to CE opportunities, influencing aspects such as value activity integration, product diversification, and location choices [67]. By comparing international and non-international micro-firms in terms of their circular economy orientation, researchers can delve into the nuanced effects of internationalization on CE practices. This comparison allows for an in-depth analysis of how exposure to diverse market demands and competition impacts the strategic mindset and operational framework related to circular economy practices within these firms. Thus, proposing that CE orientation is more strongly associated with circular economy practices in international micro-firms than in non-international micro-firms is justified by the recognition of the varied influences of internationalization on organizational strategies and approaches to sustainability initiatives.

Proposition 2 Circular economy orientation is more strongly associated with circular economy practices in international micro-firms than in non-international micro-firms.

2.4 Stakeholder pressure

Institutional pressures play a pivotal role in facilitating CE practices in micro-manufacturing firms. A critical dimension of this institutional pressure is stakeholder influence, as highlighted in studies by Adomako and Tran [68] and Baah et al. [69]. Among the key stakeholder groups, customers emerge as a primary force [70, 71], exerting significant influence from a firm's perspective on circular economy practices. For instance, considerations such as carbon and other environmental emissions can critically shape customers' purchasing decisions [72].

Employees, as another crucial stakeholder group at the firm level, have been relatively under-researched in terms of their specific role in the implementation of circular economy practices. Recent studies, however, yield interesting insights into this aspect. Employees can exert substantial pressure on their respective firms, advocating for the adoption of a sustainable circular economy and other environmentally sound practices [73]. Investors, as a significant stakeholder group, wield potentially strong influence over a firm's CE practices. Their impact can manifest as both supportive and inhibiting pressures, guiding businesses in the implementation of specific practices [74]. Additionally, NGOs and competitors within the business landscape [75] also contribute to stakeholder pressures, urging firms to adopt or enhance circular economy practices. While governance and institutional pressures undeniably has an important role on the transition to a CE, their direct impact on micro-firms may be limited. Despite prior research showcasing the influence of regulatory frameworks [76–78], micro-firms often exhibit constrained responses due to factors like resource limitations and operational focus. Their heterogeneous environmental management behaviours and resource constraints hinder uniform responsiveness to institutional pressures [79], indicating a nuanced approach is necessary when considering their role in fostering CE practices at the micro level. Governance and institutional pressures contribute to meso-level impacts such as fostering a collaborative environment [2], which can potentially benefit micro firms. However, for micro-firms to actively engage in collaborative activities, internal stimuli are crucial, including employee motivation, investor support, and engagement with immediate stakeholders [73, 74]. Additionally, responsiveness to such pressures may require acknowledgment and interaction with direct external stakeholders such as consumers and competitors [70–72]. Due to the study's exclusive focus on micro-firms and their specific dynamics, including stakeholder pressures from employees, investors, NGOs, and competitors, governance and institutional pressures were not included as a focal point, acknowledging their potential impact on broader industrial transitions to CE practices.

The intricate interplay between stakeholders and the adoption of CE practices underscores the multifaceted nature of institutional pressures faced by micro-manufacturing firms. Both international and non-international micro firms experience inherent stakeholder pressure to practice circular economy. This suggests a commonality in the challenges faced by micro-manufacturing firms, irrespective of their international status, emphasizing the universal nature of stakeholder influence on CE practices. Furthermore, international micro firms face heightened stakeholder pressure amplified by multifaceted interactions. The complexity of international business environments introduces additional layers of influence from stakeholders, intensifying the challenges and considerations for CE practices. This highlights the need for a more nuanced examination of the interactions between stakeholders and micro-manufacturing firms operating on an international scale, emphasizing the importance of considering the global context in understanding and implementing circular economy practices.

Proposition 3 Compared to non-international micro-firms, international micro-firms face heightened stakeholder pressure amplified by multifaceted interactions.

2.5 Internal barriers

A recent study by Takacs et al. [80] serves as a direct link to the construct of internal barriers identified in this literature review, aligning with the observations made by Masi et al. [67]. The body of literature addressing 'internal barriers' in the context of circular economy has witnessed significant growth in recent years. Noteworthy among these barriers are skilled manpower shortages, the need for staff training in circular practices, technological deficiencies, and challenges associated with the nature of rest and waste materials [81–83]. It is essential to highlight that these internal barriers exhibit a generic nature applicable across various manufacturing industries and firm size classes, including micro-enterprises [84].

As this review establishes the generic applicability of internal barriers across various industries and firm sizes, the proposition posits that both international and non-international micro-firms encounter internal barriers in circular economy practices. This suggests a shared experience among micro-enterprises, irrespective of their international status, reinforcing the idea that internal barriers are fundamental challenges that need to be addressed universally within the context of CE practices. International micro-firms, however, face an additional layer of complexity due to their global operations. Smaller firms often struggle with managerial barriers, such as inadequate knowledge and experience in handling foreign exchange fluctuations, which can severely impact their internationalization efforts [109]. Financial constraints are another critical internal barrier, particularly for highly productive firms that are more likely to expand abroad but face difficulties in securing the necessary external finance to shoulder the costs of entering foreign markets [110]. Moreover, the internal characteristics of small firms, such as financial and managerial constraints, personal objectives of the owners/managers, and the lack of formalized planning and control systems, act as greater constraints in shaping their exporting strategies compared to larger businesses [111]. The complexity of managing multiple markets and coordinating marketing strategies also poses a significant challenge, as firms must navigate geographic, cultural, and political barriers while maintaining a competitive advantage [112]. This study focuses on perceived internal barriers reported by firm management, potentially overlooking the complete range of challenges. While international firms face more challenges in adopting CE activities compared to non-international counterparts, international markets offer opportunities to absorb new knowledge, learn best practices, and gain crucial experience that firms solely operating domestically may lack.

These multifaceted interactions exacerbate the internal barriers faced by international micro-firms. This proposition recognises that the global nature of international business introduces additional layers of complexity to internal barriers, emphasising the need for a more nuanced examination of these challenges in the context of micro-enterprises operating on an international scale. This strategic lens provides insights into the unique contextual nuances influencing the successful integration of CE practices within the specific operational dynamics of international micro-enterprises.

Proposition 4 *Compared to non-international micro-firms*, *international micro-firms face more complex internal barriers in circular economy practices amplified by multifaceted interactions*.

The unique challenges faced by micro-firms underscore the need for a nuanced understanding of the practice of circular economy [2, 47]. This study, grounded in the fsQCA approach and utilising a complexity theory lens, conceptualizes a model (Fig. 1) to analyse data and address research propositions, explaining why different combinations of antecedent conditions can lead to CE practices in micro-manufacturing firms. The link between these factors is recognized as complex, with various configurations capable of altering the association. Complexity theory aids in specifying how CE orientation, internal barriers, environmental awareness, and stakeholder pressure interact to influence CE practices. The integration of complexity theory into the research model emphasizes the non-linear and dynamic nature of relationships between variables [26]. This approach aligns with the contention that understanding the interplay of variables requires a configuration-based perspective rather than a linear one [85].

Based on the literature review, the four propositions regarding international micro firms and their adoption of CE practices can be succinctly summarized. Proposition 1 asserts that environmental awareness is notably more integral to CE practices in international micro-firms compared to their non-international counterparts. This distinction arises from international firms' exposure to diverse global sustainability trends and regulations, compelling them to adopt stringent environmental standards to enhance competitiveness and appeal to eco-conscious consumers [8, 58]. Proposition 2 posits that international micro-firms demonstrate a stronger alignment with CE orientation, characterized by strategic frameworks emphasizing material recyclability and comprehensive CE initiatives. This orientation is fostered by internationalization, which exposes firms to varied market demands and competitive pressures, incentivizing robust CE strategies [63, 64]. Proposition 3 highlights that international micro firms face heightened stakeholder pressures, including customer expectations, investor demands, and regulatory scrutiny, all of which drive the adoption of CE practices to maintain reputation and compliance [68, 69]. Finally, Proposition 4 underscores the complex internal barriers encountered by international micro-firms in CE implementation, such as financial constraints and managerial challenges intensified by global operations [80]. These propositions collectively illuminate the distinct challenges and strategic imperatives shaping how international micro-firms navigate and integrate CE practices within a global context.

3 Research method

3.1 Data description and sample

This study employed an online survey methodology, deployed through the Qualtrics platform, accompanied by an introductory email outlining the study's objectives. Data collection occurred in three phases—comprising the baseline survey and two subsequent follow-up surveys—spanning a period of three weeks. A representative sample of 1,500 SMEs was randomly selected from the Orbis Europe database list. The structured survey was administered on January 10th, and the target population for this research was firms operating in Estonia. A total of 234 responses were collected for the study. However, to ensure the robustness of the data, the "complete case analysis" method was utilized to manage missing data [86]. Consequently, incomplete, and missing data questionnaires were omitted from the analysis. Additionally, firms failing to meet the criteria for micro-enterprises (i.e., those with more than 10 employees) were excluded from the dataset. This data curation process yielded 128 usable questionnaires, resulting in a response rate of 8.5% (128 out of 1500). Notably, this response rate is consistent with comparable survey-based studies conducted at the firm level, as evidenced in research by Abernethy et al. [87] and Kitsis & Chen [88].

Adhering to Podsakoff et al. [89], guidelines to mitigate potential common method bias, various procedures were implemented, ensuring the confidentiality and anonymity of respondent information. The study emphasises the exclusive use of results for research purposes, with randomised question ordering. The study gathered responses from a predominantly male respondent base (69.53% male). Educational backgrounds varied, with 43.75% holding a Diploma/Certificate, and the rest with university degrees. Most participants held positions as owners (82.03%), while 10.94% were managers, and 7.03% identified as having other roles within their respective firms. The respondents in the study represent various sectors of manufacturing, with the highest participation from the manufacture of furniture (14.06%), followed by the manufacture of fabricated metal products (12.50%) and the manufacture of wood and cork products (11.72%). The demographic characteristics are further detailed in Table 1.

3.2 Fuzzy-set qualitative comparative analysis (fsQCA)

The fuzzy set qualitative comparative analysis (fsQCA) is a derivative of the broader family of qualitative comparative analysis (QCA), which includes other variations such as crisp-set comparative analysis (csQCA) and multi-value qualitative comparative analysis (mvQCA). QCA is an analytical technique that combines the strengths of both qualitative and quantitative approaches to data analysis [90, 91], offering a systematic way to analyse complex relationships [91]. Thus, QCA provides a methodological middle ground that overcomes the limitations of purely qualitative or quantitative approaches to data analysis. By adopting a set-theoretic logic, QCA acknowledges the multifaceted nature of causation and allows for the exploration of equifinality—the idea that different combinations of conditions may lead to the same

Table 1 Respondents' Profile

Attributes	Description	Frequency (n)	
		(n)	%
Gender	Male	89	69.53
	Female	39	30.47
	Prefer not to say	0	0
Education	Doctorate	0	0
	Master's	33	25.78
	Undergraduate	39	30.47
	Diploma/Certificate	56	43.75
Position in the firm	Owner	105	82.03
	Manager	14	10.94
	Other	9	7.03
Industry/sector	Manufacture of furniture	18	14.06
	Manufacture of fabricated metal products, except machinery and equipment	16	12.50
	Manufacture of wood and of products of wood and cork	15	11.72
	Manufacture of wearing apparel	13	10.16
	Manufacture of machinery and equipment	12	9.37
	Manufacture of food products and beverages	12	9.37
	Manufacture of rubber and plastic products	7	5.47
	Manufacture of textiles	6	4.69
	Others	29	22.66

outcome. This is particularly advantageous in empirical research where causal pathways are intricate and varied. QCA's ability to recognise complex patterns and identify conditions that are jointly sufficient or necessary for an outcome positions it as an invaluable tool for researchers seeking a nuanced understanding of their phenomena of interest.

Among the QCA techniques, such as csQCA, conditions are typically binary coded as either 1 (present) or 0 (absent), offering a straightforward representation but lacking consideration for degrees or levels. In contrast, fsQCA introduces fuzzy logic, allowing for degrees of membership within sets, transcending rigid binary distinctions. While mvQCA expands QCA by permitting conditions to have multiple values, fsQCA goes further by incorporating fuzzy logic, facilitating the use of continuous data and improving data accuracy [91].

Considering the context of this study, circular economy practices often exist on a continuum, with organisations differing in their extent of implementation. FsQCA is particularly advantageous in this case because it allows for the representation of conditions with varying degrees of membership. This means that it can recognise different levels of circular economy practices rather than enforcing a rigid classification system, as is the case with csQCA and mvQCA [92, 93]. This flexibility makes fsQCA well-suited for capturing the variations in how organisations adopt and implement circular economy practices.

Moreover, fsQCA has been widely applied in recent years [25, 94], particularly in this research field [95–98], showcasing its adaptability and reliability. Unlike traditional regression analysis, fsQCA offers a unique advantage in handling omitted variables [99]. While regression models can introduce bias when relevant variables are omitted, particularly if the omitted variable is correlated with the included ones, fsQCA, utilising Boolean algebra, identifies causal relationships without the same bias concerns. This distinction eliminates the need for control variables, simplifying the model while maintaining its ability to robustly capture causal configurations. In fsQCA, causality is expressed through conditions being either sufficient or necessary for the outcome of interest [100]. A condition is deemed sufficient if its presence alone leads to the outcome, while it is necessary if its absence prevents the outcome [90, 91]. Unlike traditional regression analysis, which focuses on the effects of independent variables on a dependent variable, fsQCA emphasises understanding the causes of effects [100]. In other words, fsQCA examines how combinations of conditions contribute to the occurrence or absence of the outcome, rather than analysing the direct effects of individual variables on the outcome.

Thus, by applying fsQCA, we can accurately identify how environmental awareness, stakeholder pressure, CE orientation, and internal barriers combine to influence CE practices without methodological constraints in regression analysis.

Importantly, fsQCA performs relatively well with smaller datasets [91], making it practical for dividing the dataset into subsets—specifically, international and non-international micro-firms—while still ensuring robust and reliable results.

3.3 Measures

3.3.1 Outcome variable

To measure circular economy practices (CEP), we adapted Rodriguez-Espindola et al. [5] measures, which comprise 5 items. Examples include: In our company, "we have replaced non-recyclable raw materials with renewable, recyclable, or biodegradable inputs," "we work with clients/suppliers for the ecological design of products" "we are using recycled materials as inputs in our processes" and "we have policies and practices in place to dispose of machinery and equipment on time". Both the outcome variable and the condition variables were evaluated on a five-point Likert scale from 1 = totally disagree to 5 = totally agree.

3.3.2 Condition variables

To measure circular economy orientation (CEO), we developed five items based on the study of Papadas et al. [101]. For example, "My organisation provides circular economy/sustainability related training (e.g., waste minimisation, improve recycling) to our employees", "My organisation recruits new employees who understand circular economy/sustainability practices", and "We use external help for environmental sustainability support (such as sustainability consultants or support)".

We used a four-item scale adapted from Sharma et al. [102] to measure internal barriers (IB). Among these are "We have a lack of skilled manpower for the implementation of circular/sustainability practices", "We face problems related to training staff for circular practices" and "We face problems related to technological deficiencies".

To measure environmental awareness (EA), a three-item scale was used based on a study by Dey et al. [103], examples include the following: "Increasing environmental pollution (e.g., carbon emissions) poses a major threat to our society", "Firms are primarily responsible for environmental pollution" and " Adopting circular (e.g., reduce, reuse, and recycle) initiatives reduce the environmental pollution".

A six-item scale adapted from Adomako and Tran [68] was used to measure stakeholder pressure (SP). A few examples include "Employees put pressure on our company to pursue sustainable environmental practices", "Investors put pressure on our company to pursue sustainable environmental practices", "NGOs put pressure on our company to pursue sustainable environmental practices", and "Competitors put pressure on our company to pursue sustainable environmental practices".

3.4 Measurement model and descriptive statistics

We applied Harman's one-factor test to determine whether the data derived from the questionnaire survey were susceptible to common method bias [104]. Utilising STATA 17.0 statistical software, we conducted exploratory factor analysis. The results (see appendix Table 5) revealed that the first factor accounted for only 20.5% of the total variance, falling below the 50% threshold. This suggests that common method bias was not a significant concern in our dataset. Following this evaluation, we proceeded to assess the validity and reliability of the constructs.

The reliability and validity results for our constructs are presented in Table 2. All Cronbach's α values surpassed the 0.7 threshold, with the exception of "Environmental Awareness". Despite its lower Cronbach's alpha indicating less than optimal internal consistency ($\alpha = 0.573 < 0.7$), a stronger case for consistency among these items was supported by an average interitem covariance coefficient of 0.287. Recognising that Cronbach's alpha can be sensitive to latent constructs with few items [105], we supplemented this information with interitem covariances, typically seeking values ranging from 0.15 to 0.50 [106]. Additionally, we assessed the Kaiser–Meyer–Olkin (KMO) measure, which ranges from 0 to 1, indicating the degree of intercorrelations among variables. As per Hair et al. [107], KMO values above 0.5, both for the entire matrix and individual variables, signify appropriateness. In our analysis, all values exceeded this threshold, affirming the reliability and validity of most constructs under examination. Table 2 also provides a summary of descriptive statistics for the constructs, encompassing correlations, means, and standard deviations.

Table 2 Correlation matrix and measurement validity assessment

Variable	1	2	3	4	5
1. Circular Economy Practices	1.000				
2. Circular Economy Orientation	0.241	1.000			
3. Internal Barriers	−0.135	−0.118	1.000		
4. Environmental Awareness	0.036	0.120	−0.007	1.000	
5. Stakeholder Pressure	0.066	0.454	−0.011	0.084	1.000
Mean	3.788	2.588	3.035	3.784	2.206
Standard Deviation	0.082	0.078	0.075	0.062	0.070
KMO	0.776	0.739	0.674	0.584	0.825
Cronbach Alpha	0.746	0.783	0.705	0.573	0.841
Average Inter-item Covariance	0.636	0.605	0.508	0.287	0.529

4 Analysis and results

In this study, we utilised fsQCA to analyse the data, which was initially divided into two datasets, differentiating between international and non-international micro-firms. The analysis followed a three-step fsQCA process: data calibration, truth table building and truth table minimisation. In the calibration phase, we aggregated the values of indicators for each variable. We then computed the thresholds for each variable using the maximum value, average values, and minimum values in Excel. Next, we imported the dataset into the fsQCA software and calibrated using the calibration command by assigning maximal values for full membership, average values for the cross-over point, and minimal values for non-membership. Full membership indicates the extent to which a case aligns with specified characteristics, with higher values indicating a stronger alignment. Cross-over reflects cases that simultaneously belong and do not belong, represented by average values for intermediate membership. Non-membership signifies the degree to which a case lacks specified characteristics, with minimal values indicating a strong absence of association. The calibration process was performed separately for each sample (i.e., international and non-international micro-firms' dataset). In Table 3, we summarise the values used in this study.

Our next step involved building a truth table. This table presents all potential configurations, generating 2^k rows, where k denotes the number of outcome predictors, with each row representing a distinct combination. Similarly, for each sample or dataset, we developed a truth table incorporating the four specified conditions. The construction of the truth table was guided by two key criteria: by setting the frequency threshold and the level of consistency. As recommended by Pappas and Woodside [108], when dealing with a small sample, a low-frequency threshold is advised. Therefore, we set our frequency threshold to 1, indicating that a configuration must be present in at least one empirical instance to be considered. Additionally, we opted for the minimum recommended threshold of 0.75 for the consistency level [108].

Finally, we performed the data minimisation to simplify the truth table by utilising the standard analysis command. This involved identifying and merging similar configurations, thereby reducing complexity and identifying core configurations most likely to explain the desired outcome. Through this process, three distinct sets of solutions emerged: complex, parsimonious, and intermediate. The complex solution presents all the possible combinations of conditions when traditional logical operations are applied. The parsimonious solution set is a simplified version of the complex solution, based on simplifying assumptions, and presents the most important conditions which cannot

Table 3 Calibration for outcome and conditions

Threshold Variable	International micro-firms			Non-international micro-firms		
	Full membership	Cross over	Full non membership	Full membership	Cross over	Full non membership
Circular economy practices	30	18.78	5	30	19.07	11
Circular economy orientation	20	10.73	4	17	10.03	4
Internal barriers	19	12.69	4	20	11.67	4
Environmental awareness	15	11.07	6	15	11.59	3
Stakeholder pressure	20	13.20	6	23	13.26	6

be left out of any solution. The intermediate solution is obtained when performing counterfactual analysis on the complex and parsimonious solutions including only theoretically plausible counterfactuals.

Following Pappas and Woodside's [108] recommendation, we considered the intermediate solutions to determine the causal configurations. Comparing these with the parsimonious solution, we determined both core and peripheral conditions within the configurations. Core conditions are determined when conditions consistently appear across both the parsimonious and intermediate solutions. Conversely, conditions present solely in intermediate solutions, but absent in the parsimonious solution, are regarded as peripheral conditions. The following subsections present the fsQCA results.

4.1 Causal configuration for circular economy practices in international micro firms

Three distinct configurations are identified to explain CE practices in international micro-firms, all exceeding the required minimum consistency threshold (> 0.75). The results indicate that CE orientation, as represented by configuration A1, functions as a core condition. In this specific configuration, it stands independently, emphasizing the central role of circular economy orientation in practicing circular economy. In addition, this configuration exhibits a high degree of consistency (0.841), which covers 21.5% of the membership in the outcome. The configuration A2, indicates that the coexistence of stakeholder pressure and environmental awareness, both in a peripheral state, are sufficient to drive these firms to adopt circular economy practices. This configuration exhibits a fair level of consistency (0.763) and covers 1.4% of the membership in the outcome. In the final configuration (A3), stakeholder pressure appears as a core condition, offsetting the presence (albeit in a peripheral role) of internal barriers to circular economy practices. This configuration exhibits a significant level of consistency (0.803) and accounts for 1.1% membership in the outcome.

4.2 Causal configuration for circular economy practices in non-international micro firms

For non-international micro firms, two configurations are observed, both exceeding the required minimum consistency threshold (> 0.75). Configuration B1, requires the absence of internal barriers and, at a minimum, CE orientation and environmental awareness as peripheral conditions for circular economy practices. This configuration exhibits a high consistency level of 0.829 and covers 9.1% membership in the outcome. The second configuration (B2) three conditions—CE orientation, environmental awareness, and stakeholder pressure—are identified as core conditions for non-international firms to adopt circular economy practices. This configuration, characterised by a robust consistency level of 0.817, covers 5.4% membership in the outcome (Table 4).

Table 4 fsQCA analysis of the configurational combinations between international and non-international micro-firms

	International micro-firms			Non-international micro-firms	
Conditions	A1	A2	A3	B1	B2
Circular Economy Orientation	●			•	●
Internal Barriers			•	○	
Environmental Awareness		•		•	●
Stakeholder Pressure		•	●		●
Raw coverage	0.781	0.522	0.524	0.571	0.534
Unique coverage	0.215	0.014	0.011	0.091	0.054
Consistency	0.841	0.763	0.803	0.829	0.817
Solution coverage	0.835			0.625	
Solution consistency	0.762			0.798	

Black dots indicate the presence of causal conditions and white dots indicate the absence or negation of causal conditions. Large dots; core conditions, small dots, peripheral conditions, blank space; "don't care" conditions. Sample size: International micro-firms = 59; non-international micro-firms = 69

5 Discussion

The identification of the conditions driving CE practices aligns with existing research emphasizing the importance of factors such as CE orientation, environmental awareness, internal barriers and stakeholder pressure [10, 11]. The findings of this study shed light on the complex interplay of organizational aspects influencing CE practices in micro-manufacturing firms, both at the international and non-international levels, adding nuance to these findings and emphasizing the unique challenges and opportunities faced by micro-enterprises in embracing CE practices. Each identified causal configuration offers valuable insights into the nuanced dynamics shaping CE adoption, building upon prior literature while introducing new perspectives.

In international micro-firms, Configuration A1 underscores the pivotal role of CE orientation as a core condition driving the adoption of circular practices. This finding aligns with prior literature highlighting the strategic importance of embracing circular economy principles [60, 62]. Firms with a strong CE orientation are likely to integrate circularity into their business models, emphasizing resource efficiency and sustainable production processes [63, 64]. Configuration A2, which emphasizes the coexistence of stakeholder pressure and environmental awareness, suggests that external influences play a significant role in shaping CE practices in international micro-firms. This finding resonates with studies emphasizing the importance of stakeholder engagement and environmental consciousness in driving sustainability initiatives [68, 69].

Interestingly, Configuration A3 highlights the prominence of stakeholder pressure as a core condition, even in the presence of internal barriers. This finding underscores the influence of external pressures, such as regulatory mandates and consumer expectations, in compelling firms to adopt circular practices [70, 71]. Moreover, the presence of internal barriers, albeit in a peripheral role, suggests that while challenges may exist, they can be mitigated by external stimuli and organizational commitment to sustainability [72, 73].

In contrast, non-international micro-firms exhibit distinct patterns of CE adoption. Configuration B1 emphasizes the importance of the absence of internal barriers (or overcoming them) and embracing CE orientation and environmental awareness as peripheral conditions for CE practices. This finding suggests that non-international micro firms may face internal challenges in adopting circular practices, but these barriers can be overcome with a strong organizational commitment to sustainability and awareness of environmental issues [74, 75]. Configuration B2 highlights the core role of CE orientation, environmental awareness, and stakeholder pressure in driving CE practices in non-international micro-firms. This finding underscores the multifaceted nature of influences shaping CE initiatives in micro-enterprises, emphasizing the need for a holistic approach to addressing internal and external factors.

Overall, the identified causal configurations offer nuanced insights into the pathways through which organizational aspects influence CE practices in micro-manufacturing firms. By integrating these findings with prior literature, we gain a deeper understanding of the complex interplay between internal dynamics and external pressures in driving CE practices. These insights are crucial for informing policy interventions and managerial strategies aimed at promoting CE practices in micro-firms, ultimately contributing to the broader transition towards a more sustainable economic model [82, 83].

5.1 Theoretical implications

Even though there is an increasing number of research that has tried to understand what internal and external factors influence activities towards CE in general [31, 32, 55] and SMEs [48, 50], there is to our knowledge a shortage of studies that have examined the influence of selected organizational aspects on CE practices in firms, and micro-firms in particular. By utilising a configurational fsQCA, we examined the role of the selected organisational aspects in conjunction with CE practices in international and non-international micro-firms. Figure 1 offers a comprehensive understanding of the multifaceted nature of CE practices, emphasizing the need for a nuanced approach to address the challenges faced by micro-firms in adopting CE practices. The study's findings are relevant for ongoing debates in the areas of sustainable business development and strategy management dedicated to small firms and advance our understanding of the readiness of micro-firms regarding CE practices.

The theoretical significance extends further through the use of a nonlinear method, the fsQCA method. This approach enables a comprehensive exploration of the factors influencing circular economy practices, providing deep insights into the realm of international and non-international micro-manufacturing firms. The application of fsQCA unveils multiple pathways, elucidating how diverse combinations of constructs impact circular economy practices in these firms. Furthermore, the integration of complexity theory into the research model underscores the dynamic nature of these relationships, emphasizing the non-linear and emergent patterns that influence CE practices over time. This perspective acknowledges that the effectiveness of CE initiatives is contingent upon various contextual factors and interactions between organizational elements. Through Fig. 1, this study provides insights into how different configurations of antecedent conditions influence the adoption and implementation of CE practices in micro-manufacturing firms. Beyond theoretical implications, the study's findings from causal models offer practical guidelines for managers, empowering them to take informed actions concerning the factors influencing the adoption of circular economy practices. Overall, the theoretical contributions of this research extend beyond mere identification, offering a nuanced understanding and practical insights that enrich the scholarly discourse on circular economy practices in micro-manufacturing firms.

5.2 Practical implications

The results of the study have practical implications for micro-firms as they can help them to better understand different influencing factors and their importance for the introduction of CE practices. The identified configurations provide relevant insights that can be used to promote CE practices in international and non-international micro-manufacturing companies. Decision makers in these companies can learn a lot from configurations about the necessary internal, external or mixed conditions for the practicing of CE.

Micro-enterprises should carefully analyse the paths and take the one that is best suited to their specific organisational context. The findings underline that there is not just one solution, but that a micro-enterprise can take different paths depending on the situation to achieve the desired goal. Decision makers should recognise that the introduction of CE practices may not solely depend on one aspect but on the interplay between multiple conditions.

Path A1: The key to the implementation of successful CE practices lies in developing and cultivating a strong sustainability orientation. This approach underscores the importance of fostering a culture where environmental considerations are integrated into daily operations and decision-making processes. Managers should emphasize sustainability education and training to ensure all employees understand, acknowledge and hence actively contribute to the firm's CE related goals. At the same time, managers should focus on integrating sustainability principles into their organisational culture and strategy.

Path A2: Internationally operating micro-enterprises can promote successful CE practices by simultaneously considering the role of environmental awareness and stakeholder pressure. These companies are aware of the importance of external factors and try, within their means, to keep abreast of global sustainability trends. They comply with the various environmental regulations. As these companies proactively respond to the expectations and demands of stakeholders, this allows them to build and strengthen their reputation. Internal barriers or sustainability orientation may not be as critical in this context.

Path A3: This path emphasises the need for building strong stakeholder relationships while simultaneously addressing internal obstacles. For micro-firms opting for this path, success in CE practices depends on developing and maintaining constructive dialogues and relationships with the relevant stakeholders. Sustainability orientation and environmental awareness may not be as crucial for adopting successful CE practices.

Path B1: Non-international micro-firms aiming for effective CE practices should prioritise sustainability orientation and environmental awareness. Non-international micro-enterprises aiming for CE practices should prioritise sustainability orientation and environmental awareness. These companies prioritise measures aimed at embedding sustainability awareness throughout the company and engaging employees on environmental issues and their impact on business operations. By fostering a culture of environmental responsibility and awareness, these companies can lay the foundation for successful CE adoption, even in the face of potential internal barriers. Stakeholder pressure does not play a significant role in this path. Managers should concentrate on developing a sustainability-oriented mindset.

Path B2: This path calls for a holistic approach. These non-international micro-firms recognise the interconnectedness of different factors, i.e., sustainability orientation, environmental awareness, and stakeholder pressures. By taking these three core conditions into account at the same time, managers can develop a balanced strategy. This approach enables the creation of a robust basis for the integration of CE principles into corporate activities and, ideally, the improvement of long-term sustainability performance.

6 Conclusion

In conclusion, this study delves into the complex interplay of key constructs—namely circular economy practices, environmental awareness, circular economy orientation, stakeholder pressure, and internal barriers—in the context of internationally and non-internationally operating micro-manufacturing firms. In addition, the empirical findings of this research unveil five distinct pathways toward circular economy practices, with three pathways identified in international micro-manufacturing firms and two in non-international micro-manufacturing firms. This nuanced exploration contributes valuable insights into the contextual variations shaping the adoption of sustainable practices within micro-enterprises, further enriching the understanding of circular economy dynamics in the manufacturing sector, by offering theoretical and practical implications.

The study is limited by the exclusive use of the fsQCA method. While fsQCA provides a robust framework for analysing complex causal configurations [55], it is essential to acknowledge that every analytical technique has its constraints. For instance, fsQCA does not explicitly account for temporal order, which may pose challenges in establishing the directionality of causal relationships. Future research could explore incorporating temporal elements or combining fsQCA with other analytical approaches to provide a more comprehensive understanding of causal relationships. Additionally, the study's focus on specific configurations within micro-manufacturing firms in Estonia raises concerns about the generalizability of findings to other geographical, industrial and business contexts. Acknowledging this limitation, future research should prioritize investigating circular economy practices in different contexts, aiming to refine and broaden our understanding of the factors supporting or hampering the transition toward CE. Future research should also delve into both the perceived and actual internal barriers that international micro firms face when adopting CE practices. It should explore how operating in international markets allows these firms to not only confront challenges but also absorb new knowledge, learn best practices from diverse regulatory environments, and adapt to varying cultural and competitive landscapes. In addition, research should investigate how the internationalization of micro firms influences the development of CE orientation and environmental awareness. International firms are exposed to diverse stakeholder pressures and regulatory environments across different markets, which may catalyse the adoption of CE practices and sustainability strategies. By examining these dynamics, researchers can uncover how internationalization fosters CE practices.

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Data availability The datasets generated during and/or analysed during the current study are available from the corresponding author upon reasonable request.

Declarations

Ethics approval and consent to participate An ethics approval was not required for this study as the data is not considered to be sensitive or confidential in nature. Vulnerable or dependent groups were not included. The subject matter was limited to topics that are strictly within the professional competence of the participants. Participants gave their informed consent by conducting the study, i.e., by starting (completing) the online questionnaire.

Competing interests The authors have no competing interests to declare that are relevant to the content of this article.

Appendix

See Table 5

Table 5 Exploratory factor analysis

Factor	Eigenvalue	Difference	Proportion	Cumulative
Factor1	4.51487	1.77127	*0.2052	0.2052
Factor2	2.7436	0.58305	0.1247	0.3299
Factor3	2.16055	0.34331	0.0982	0.4281
Factor4	1.81723	0.29947	0.0826	0.5107
Factor5	1.51776	0.46563	0.069	0.5797
Factor6	1.05213	0.04433	0.0478	0.6276
Factor7	1.00781	0.11967	0.0458	0.6734
Factor8	0.88814	0.05852	0.0404	0.7137
Factor9	0.82962	0.13729	0.0377	0.7514
Factor10	0.69233	0.02441	0.0315	0.7829
Factor11	0.66792	0.08863	0.0304	0.8133
Factor12	0.57929	0.03542	0.0263	0.8396
Factor13	0.54387	0.05419	0.0247	0.8643
Factor14	0.48968	0.08848	0.0223	0.8866
Factor15	0.4012	0.00875	0.0182	0.9048
Factor16	0.39246	0.04027	0.0178	0.9227
Factor17	0.35219	0.02429	0.016	0.9387
Factor18	0.3279	0.0228	0.0149	0.9536
Factor19	0.3051	0.04772	0.0139	0.9674
Factor20	0.25738	0.02174	0.0117	0.9791
Factor21	0.23563	0.01229	0.0107	0.9898
Factor22	0.22334		0.0102	1

*Should be < 0.50 (Podsakoff and Organ, 1986)

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