



The Lean-Circular Transition in Morocco: Evidence from the Manufacturing and Construction Sectors

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Abstract: The depletion of natural resources and growing environmental pressure have prompted interest in linking Lean management and the circular economy as complementary approaches to sustainable industrial transformation. This article offers a narrative review of the literature on how both paradigms interact, with particular attention to the Moroccan context, an angle still scarcely explored in the specialised literature. It examines the synergy mechanisms, enabling conditions, barriers and performance outcomes documented in recent studies on Moroccan manufacturing and construction SMEs. The review shows that Lean tools such as value stream mapping and 5S frequently serve as operational foundations for implementing circular economy principles. Persistent tensions are also identified, among them the risk of a narrow interpretation of Lean, which may constrain the systemic thinking that genuine circularity requires. The Moroccan evidence reveals that small and medium-sized enterprises increasingly draw on Circular Lean Six Sigma 4.0 and Lean Construction practices, although institutional barriers, particularly around public procurement governance, continue to constrain their translation into sustained circular outcomes. The synergy between Lean and the circular economy holds considerable potential, whose realisation requires rethinking Lean from a broader value-retention perspective, adapted to Morocco's institutional conditions.

Keywords: Lean management ; circular economy ; small and medium-sized enterprise ; developing economies ; Morocco.

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1. Introduction

The contemporary industrial landscape faces a dual challenge. On the one hand, organisations must improve their operational efficiency. On the other, they must respond to mounting environmental crises stemming from resource depletion, waste generation and climate change. For decades, Lean management has constituted the dominant paradigm of operational excellence. Centred on the systematic elimination of waste to maximise the value delivered to the customer, this philosophy draws on tools such as Just-in-Time, Kaizen and standardised work (Liker, 2020). Its conceptual core lies in eliminating non-value-adding activities, understanding waste in economic and operational rather than environmental terms (Garza-Reyes, 2015).

In parallel, the circular economy has emerged as a transformative framework for sustainable development. It challenges the traditional linear model of extracting, producing and discarding (MacArthur, 2013) and proposes instead a restorative and regenerative industrial system, whose purpose is to decouple economic growth from the consumption of finite resources (Geissdoerfer et al., 2017). Its principles are operationalised through strategies such as the 9R framework, which prioritises value-retention options superior to simple recycling (Bocken et al., 2016). Adopting the circular economy further requires a fundamental shift in business models and product design, oriented towards durability and reparability.

Despite their different origins, Lean and the circular economy share a common conceptual foundation: waste reduction. This convergence has given rise to a growing body of research exploring the potential synergies between the two paradigms. The central idea is that the Lean toolkit for identifying and eliminating waste can act as an operational enabler for implementing circular economy strategies. Value stream mapping, for instance, can be extended to trace material flows, while 5S can be adapted to improve waste segregation (Garza-Reyes, 2015).

The relationship between the two paradigms is not, however, free of tension. A narrow interpretation of Lean, centred on process and cost reduction, can inadvertently hinder the systemic thinking that genuine circularity requires (Negrão et al., 2017). The Lean emphasis on just-in-time delivery, for example, can translate into smaller and more frequent shipments, which increases transport emissions (Garza-Reyes, 2015). Likewise, Lean's characteristic elimination of inventory can conflict with the need to maintain buffer stocks in reverse logistics systems (Govindan & Hasanagic, 2018).

Despite growing interest in this intersection, the available literature presents significant gaps. Existing studies concentrate predominantly on large manufacturing firms in industrialised economies, with a pronounced bias towards qualitative case studies. The enabling conditions and barriers to successful integration are, moreover, often discussed in isolation, without a clear understanding of how organisational, technological and regulatory factors interact. Above all, the geographical dimension of the phenomenon has remained largely unexplored, as recent literature is only beginning to document experiences among small and medium-sized enterprises in developing African economies.

The purpose of this article is to offer an organised reading of this literature, explicitly incorporating a focus on developing economies in Africa, with particular attention to Morocco. It seeks to identify the mechanisms through which Lean tools enable or hinder the implementation of the circular economy in the Moroccan context. The article first presents the conceptual framework, followed by the methodological approach, sectoral applications, the Moroccan evidence, the discussion and the conclusions.

2. Conceptual Framework on Lean Management and the Circular Economy

Lean management is a continuous-improvement philosophy oriented towards maximising customer value. Its method consists of systematically eliminating the classic forms of waste, including

overproduction, waiting, unnecessary transport, excess inventory and defects (Liker, 2020). Tools such as value stream mapping, 5S and Kaizen constitute the operational repertoire through which organisations diagnose and reduce these sources of inefficiency. The circular economy, for its part, proposes a restorative and regenerative industrial system, structured around three guiding principles: eliminating waste by design, keeping products and materials in use for as long as possible, and regenerating natural systems (MacArthur, 2013).

The 9R framework ranks these strategies from the options with the highest value retention, such as refuse and reduce, down to lower-order options such as energy recovery (Bocken et al., 2016). This hierarchy is useful for distinguishing between a shallow circular economy, centred on recycling, and a deeper circular economy, oriented towards preventing waste at its source.

Comparing the two paradigms reveals a difference in scope that is central to understanding their relationship. Whereas Lean conceives of waste in economic and operational terms within the boundaries of the firm, the circular economy adopts a systemic perspective spanning raw-material extraction, product design and end-of-life recovery (Geissdoerfer et al., 2017). This difference conditions the extent to which Lean tools can, or cannot, translate into circularity outcomes. Adapting value stream mapping to incorporate environmental metrics allows, for example, the identification of loop-closing opportunities that conventional Lean tools do not make visible (Marquina et al., 2021). In this regard, the review by Govindan and Hasanagic (2018) identifies reverse logistics as a component that Lean tends to undervalue.

In any case, the Lean-circularity relationship is not automatic. It depends on a deliberate reformulation of the concept of waste. The case of a Swedish heavy-equipment manufacturer illustrates this point well: the firm remained trapped in a linear paradigm in which material waste was not perceived as a recoverable resource (Schmitt et al., 2021). In response to this limitation, more recent conceptual frameworks, such as C-Learn (Nadeem et al., 2023) and Hoshin Kanri adapted to sustainability (Reke et al., 2022), extend the scope of Lean towards a perspective compatible with circularity.

3. Methodological Approach of the Review

This article is based on a narrative review of the academic literature on the relationship between Lean management and the circular economy. Unlike a systematic review, this approach does not aim to be exhaustive or to follow a rigid search protocol. Its purpose is rather interpretive, offering a critical and organised reading of the most relevant studies available in indexed academic journals, conference proceedings and book chapters.

The search for sources was conducted mainly in databases such as Scopus, Web of Science, ScienceDirect and Google Scholar, combining terms related to Lean management and the circular economy. Priority was given to studies that explicitly address the interaction between the two paradigms, particularly those focused on small and medium-sized enterprises in developing economies, since this aspect constitutes the distinctive focus of the present review. Studies were organised thematically, grouping sectoral contributions, conceptual frameworks and empirical works, before proceeding to the Moroccan evidence developed later in the article.

4. The Lean–Circular Economy Synergy in Industrial Practice

The literature on the Lean-circular economy synergy stems mainly from concrete sectoral applications. These applications show how Lean tools can, or cannot, translate into circularity outcomes depending on the industrial context. They are complemented by conceptual frameworks and a number of quantitative empirical studies that help nuance the findings of the case studies.

4.1 Applications in Manufacturing, Construction and Other Sectors

In the plastics industry, a Lean-green production model that integrated 5S, Kanban and total productive maintenance, combined with a reuse-oriented circular economy approach, reduced input procurement by 11% and machinery breakdowns by 4% in a small firm (Diaz et al., 2021). In the furniture industry, value stream mapping combined with the 6R strategy facilitated the reuse of wood waste as raw material for derivative products (Hartini et al., 2021). These cases suggest that even the simplest Lean tools, applied with explicit circular intent, already generate tangible benefits in smaller-scale plants.

Not all cases are equally encouraging. That of a Swedish heavy-equipment manufacturer proved more problematic, as the firm remained anchored in a linear paradigm in which waste was not perceived as a resource (Schmitt et al., 2021). This contrast underscores an important point: the synergy between Lean and circularity is not automatic. It requires a deliberate reformulation of the Lean concept of waste, something many organisations have yet to undertake.

In the construction sector, the evidence is more mixed. A UK multi-method study found nuanced quantitative results regarding the contribution of Lean construction to sustainability, whereas the qualitative findings of the same study did evidence a meaningful role for Lean construction (Maqbool & Narayanan, 2026). This discrepancy suggests that the effects of Lean on circularity may be more difficult to measure than they appear, particularly in fragmented sectors such as construction, where multiple contractors are involved in a single project.

In retail, an Italian supermarket applied the Lean Six Sigma DMAIC methodology to improve its waste management, assessing environmental performance through carbon footprint analysis. The study found that anaerobic digestion generates fewer emissions than composting (Marrucci et al., 2020). In the remanufacturing sector, inherently circular given its focus on extending product life, a study of four companies identified ten key challenges and proposed seven Lean-based improvements, projecting lead-time reductions of between 83% and 99% (Kurilova-Palisaitiene et al., 2018). These results, although promising, come from a small number of cases and should be interpreted with caution.

The agricultural sector, although less represented in the general literature, offers additional examples of integration in developing economies. The textile sector has also documented applications combining Lean, Industry 4.0 and the circular economy. On a broader scale, a cross-case analysis of the automotive, consumer goods and technology sectors documented cost reductions of up to 30% through the joint application of Lean and the circular economy in firms such as Toyota and Renault, while also identifying organisational resistance and insufficient reverse-logistics infrastructure as persistent obstacles (Marques et al., 2026).

4.2 Conceptual Frameworks and Empirical Evidence

Beyond case studies, several works have proposed conceptual frameworks to structure the integration between Lean and the circular economy. Notable among them are the C-Lean framework, aimed at manufacturing SMEs (Nadeem et al., 2023), the adaptation of Hoshin Kanri to align sustainability objectives (Reke et al., 2022), and the 3P model designed to guide SMEs in their transition towards the circular economy (Caldera et al., 2019). The analysis by Kalemkerian et al. (2022) of green Lean case studies revealed, for its part, that most implementations were oriented towards minimising waste rather than closing production loops, suggesting that the current contribution of green Lean to circularity remains limited.

The available quantitative evidence nuances these conceptual findings. A large-scale panel study of Chinese manufacturers identified an inverted-U relationship between inventory leanness, a central Lean principle, and circular economy performance (Fang et al., 2025). Excessive focus on inventory

reduction can, in other words, prove counterproductive, as it weakens the buffer stocks needed for reverse logistics. A quasi-experimental study on water circularity through 5S in SMEs, for its part, demonstrated significant improvements without compromising plant productivity (Sartal et al., 2020).

5. Finding: The Lean-Circular Transition in Morocco

One of the most significant gaps in the general literature on the Lean-circular economy synergy is its pronounced bias towards large firms in industrialised economies. SMEs in developing economies such as Morocco receive, by comparison, considerably less attention. The available studies on the Moroccan case, although still relatively scarce, make it possible to document this trajectory in some depth, which constitutes the distinctive contribution of this article.

5.1 Evidence from Manufacturing and Construction

In Morocco, the available evidence comes mainly from the manufacturing sector. A qualitative exploratory multiple-case study documented that Circular Lean Six Sigma 4.0 practices are geared towards promoting manufacturing sustainability, driven by expected operational performance and the pursuit of competitive advantage, although they face barriers related to insufficient resources and management support (Skalli et al., 2023). A second study, based on structural equation modelling, confirmed that the combination of Lean Six Sigma, the circular economy and Industry 4.0 technologies exerts a positive effect on sustainable organisational performance, although the effect of Industry 4.0 on the circular economy proved to be mediated by Lean Six Sigma rather than direct (Skalli et al., 2024).

In the Moroccan construction sector, a two-round Delphi study with 22 experts identified 40 critical barriers to implementing a framework integrating Lean construction, the circular economy and digitalisation. The constraints are concentrated mainly in pre-execution project governance, the absence of circularity-oriented procurement guidelines, and the lack of circularity requirements in tendering processes (Hafiane et al., 2026).

5.2 Implications for Moroccan SME and Public Management

For public and business management in Morocco, this evidence suggests that leveraging Lean tools for circularity requires institutional support that extends beyond the technical Lean toolkit, already relatively consolidated in Moroccan manufacturing and construction. It should also reach the institutional mechanisms that condition their translation into sustained circular outcomes: public procurement governance, organisational learning within SMEs, and broader access to financing for circular investments.

6. Discussion

The literature reviewed reveals a complex relationship between Lean management and the circular economy, marked by genuine synergies, persistent tensions and a strong dependence on context. The evidence suggests that this synergy is neither automatic nor guaranteed. It requires deliberate strategic alignment and a fundamental reformulation of the Lean concept of waste. The most consistent finding is that Lean's own diagnostic repertoire, particularly value stream mapping, 5S and Kaizen, offers a practical basis for identifying circularity opportunities, especially in organisations that already possess mature operational discipline.

At the same time, the evidence reviewed reveals tensions that call a direct synergy into question. The case of the Swedish manufacturer trapped in a linear paradigm (Schmitt et al., 2021) and the inverted-U relationship between inventory leanness and circular economy performance (Fang et al., 2025) illustrate this point well. Both suggest that Lean and the circular economy are not simply

complementary. Their underlying logics are, rather, partially conflicting, since Lean eliminates waste within the boundaries of the firm while the circular economy adopts a full life-cycle perspective. Conceptual frameworks such as C-Lean (Nadeem et al., 2023) and Hoshin Kanri adapted to sustainability (Reke et al., 2022) represent important steps towards this reformulation. They remain, however, largely conceptual at this stage. Their empirical validation is still limited, which leaves an important question open for future research: whether these frameworks withstand the test of real-world implementation across diverse organisational contexts.

The Moroccan evidence reviewed further enriches this discussion. It shows that the tensions and enabling conditions documented in the general literature take on distinctly institutional and regulatory contours in this context. Moroccan SMEs appear to benefit particularly from adapting Lean tools for circularity purposes, since they tend to face more severe resource constraints than large firms in industrialised economies (Nadeem et al., 2023; Caldera et al., 2019). The literature reviewed emphasises public governance barriers, procurement guidelines, tendering requirements, pre-execution project governance, as the primary constraint on translating Lean gains into sustained circular outcomes, suggesting that policies to foster the Lean-circular synergy in Morocco should prioritise these institutional levers.

Several limitations of this review should be acknowledged. Being a narrative review, the selection of studies partly reflects the authors' judgement rather than an exhaustive search protocol. The restriction to English-language publications may, moreover, have excluded relevant work in French or Arabic, a bias particularly pertinent to the Moroccan literature. Finally, the quality of the studies reviewed varies considerably, and several case studies lack the methodological rigour needed to generalise their conclusions.

7. Conclusions

This narrative review examined the available literature on the synergy between Lean management and the circular economy, paying particular attention to how the two paradigms interact to enable sustainable industrial transformation. The literature consulted shows that Lean tools such as value stream mapping and 5S frequently serve as operational foundations for implementing circular economy principles. It also reveals persistent tensions, including the risk of a narrow interpretation of Lean that can constrain the systemic thinking that genuine circularity requires.

The contribution of this review lies in reformulating the Lean-circular economy relationship as one characterised both by genuine synergies and by underlying tensions, rather than as simple complementarity. The focus on Morocco adds a still under-explored African dimension to this reformulation. It shows that Moroccan SMEs draw on an increasingly structured Lean repertoire, including Lean Six Sigma, Lean Construction and Industry 4.0 integration, while facing institutional barriers rooted primarily in public procurement governance and pre-execution project governance.

For managers of SMEs in Morocco, the synthesised evidence suggests that integrating Lean and the circular economy requires a shift in mindset and organisational capabilities, underpinned by management commitment and continuous learning. For policymakers, the findings point to the need to develop regulatory frameworks that incentivise circularity, such as public procurement guidelines incorporating environmental criteria (Hafiane et al., 2026), and to facilitate access to financing that supports circular investments among SMEs.

Future research should prioritise longitudinal studies capturing the dynamic nature of the Lean-circular economy integration process. It would also be valuable to develop and validate institutionally sensitive models, as well as to expand the empirical evidence on Moroccan SMEs across a wider range of sectors and regions, and to situate these findings within the broader African context through future

comparative work. The available evidence, although promising, remains limited both in volume and in geographical representativeness.

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