

Building Circular Supply Chains through Digital Technologies



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In the article by Al-Swidi et al. (2025), “Harnessing digital technologies in circular supply chains: the role of technological opportunism capability and technological turbulence,” the authors explore how firms can effectively develop circular supply chain capability in an era of rapid digital transformation, focusing on the role of digital technologies, technological opportunism capability, and technological turbulence. Using empirical evidence from the Indian automotive industry, the study provides a nuanced explanation of why some firms can operationalize circular economy principles while others struggle, despite similar environmental pressures.

At the heart of the study is the argument that digital technologies are not optional add-ons but essential enablers of circular supply chains. The authors demonstrate that technologies such as the Internet of Things, blockchain, and big data analytics play a decisive role in enabling firms to manage material flows, improve traceability, support reverse logistics, and reduce waste across the supply chain. Firms that adopted these technologies were significantly more capable of implementing circular practices, confirming that digitalization forms the operational backbone of circular supply chain capability. Without digital tools, efforts towards circularity remain fragmented, difficult to scale, and largely symbolic. Figure 1 illustrates the study model.

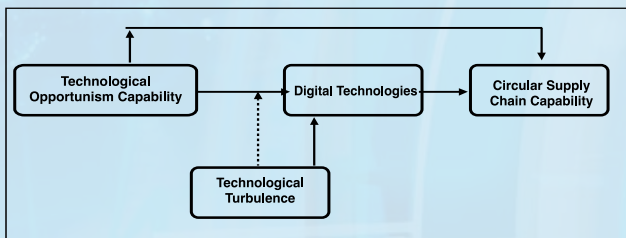


Figure 1: Study Framework.

However, the study goes beyond simply stating that digital technologies matter. It investigates how firms come to adopt these technologies in the first place, particularly in uncertain and fast-changing environments. Here, the concept of technological opportunism capability becomes central. Technological opportunism refers to a firm's ability to sense emerging technologies and respond quickly by reallocating resources and adjusting strategies. The findings show that firms with strong technological opportunism capability are significantly more likely to adopt advanced digital technologies. These firms actively scan their environments, recognize technological opportunities early, and move faster than competitors in experimenting with and deploying new tools. Crucially, the study reveals that technological opportunism capability does not directly improve circular supply chain capability. This is one of the article's most important and counterintuitive findings. While opportunistic firms are better at identifying new technologies, this capability alone does not automatically translate into circular outcomes. In other words, being

alert to technological opportunities is insufficient unless it leads to concrete investments in digital systems. The analysis shows that technological opportunism influences circular supply chain capability only through digital technology adoption, establishing a case of full mediation. This finding clarifies a key ambiguity in prior research and underscores that dynamic capabilities must be operationalized through tangible systems before they generate performance benefits.

The study further examines the role of technological turbulence, defined as the speed and unpredictability of technological change in the external environment. The results indicate that technological turbulence has a direct positive effect on digital technology adoption. In highly turbulent environments, firms face greater uncertainty, shorter technology life cycles, and stronger competitive pressure, which motivates them to adopt digital tools as a way to maintain control, visibility, and flexibility in their supply chains. Digital technologies become a response mechanism to environmental volatility.

More importantly, technological turbulence strengthens the relationship between technological opportunism capability and digital technology adoption. When the technological environment is stable, even firms with modest opportunism can keep pace with incremental change. However, under high turbulence, differences between firms become pronounced. Opportunistic firms gain a clear advantage because their sensing and responding capabilities allow them to act decisively in the face of rapid change. In such environments, technological opportunism becomes a critical differentiator that accelerates digital adoption and, indirectly, circular supply chain capability.

Taken together, the findings, as presented in Table 1 and Figure 2, present a coherent causal chain. Firms that cultivate technological opportunism are better positioned to adopt digital technologies, particularly when technological turbulence is high. These digital technologies, in turn, enable the development of circular supply chain capability. The study, therefore, reframes circular supply chain transformation as a capability-building process, rather than a simple compliance or





sustainability initiative. Circularity emerges not from intentions alone, but from the interaction between organizational capabilities, digital infrastructure, and environmental conditions.

Table 1: Data Analysis Results.

Structural path analysis results.								
H	Path	β	Std Error	t-value	p	LL	UL	Result
H1	DTs → CSCC	.591	.055	10.760	.000	.479	.693	Supported
H2	TOC → DTs	.453	.050	9.192	.000	.361	.556	Supported
H3	TOC → CSCC	.106	.057	1.874	.061	-0.002	.222	Not supported
H5	TT → DTs	.278	.055	5.057	.000	.160	.385	Supported

Source: Authors' analysis.

Mediation analysis results.								
H	Path	β	Std Error	t-value	p	LL	UL	Result
H4	TOC → DTs → CSCC	.271	.035	7.712	.000	.204	.343	Supported (Full mediation)

Source: Authors' analysis.

Structural path analysis results.								
H	Path	β	Std Error	t-value	p	LL	UL	Result
H6	TOC*TT → DTs	.180	.042	2.916	.044	.005	.160	Supported

Source: Authors' analysis.

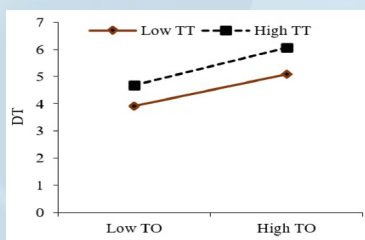


Figure 2: Moderation analysis of technological turbulence.

The article makes several important theoretical contributions. It integrates Technology–Organization–Environment (TOE) theory with Dynamic Capabilities Theory, demonstrating how organizational capabilities and environmental turbulence jointly shape technology adoption and sustainability outcomes. By showing that digital technologies fully mediate the relationship between technological opportunism and circular supply chain capability, the study resolves conflicting assumptions in prior research about the direct impact of managerial or technological orientation on sustainability

performance. It also enriches circular economy research by providing empirical evidence from an emerging economy, where resource constraints, regulatory pressures, and technological gaps create a particularly challenging context for circular transformation.

From a managerial perspective, the findings carry clear implications. Managers seeking to advance circular supply chains must move beyond high-level sustainability rhetoric and invest decisively in digital technologies that enable traceability, analytics, and coordination across the supply chain. At the same time, firms should actively develop technological opportunism through environmental scanning, flexible decision-making structures, and a culture that supports experimentation. Importantly, managers should recognize that such capabilities are most valuable in turbulent technological environments, where speed and adaptability determine success. Policymakers, in turn, can support circular transitions by reducing barriers to digital adoption and by fostering ecosystems that encourage experimentation and learning.

In conclusion, the study demonstrates that digital technologies are the central mechanism through which firms translate technological awareness into circular supply chain capability. Technological opportunism acts as an enabler rather than a direct driver, and its effectiveness depends heavily on the level of technological turbulence in the environment. By illuminating these relationships, the article provides a robust, empirically grounded explanation of how firms can navigate digital transformation to achieve meaningful and scalable circular supply chain outcomes.