Blockchain-Enabled Sustainability Transparency in Omani SMEs: Empirical Evidence on Drivers, Green Trust, and Competitive Advantage

Noura Said AL-Jahwari[1], Vathana Bathmanathan[2], Ahmed Abubakar[3], Adil Hassan Bakheet[4], Ibrahem Al. Farsi[5], Papiya Bhattacharya[6], Reena Raut[7], Saleh Fadel Ahmad Khatib[8]

[1,3,4,5,6,8], Sohar University Oman,
[2]Universiti Tenaga Nasional Malaysia
[7]Symbiosis Institute of Operations Management, Nashik campus, constituent of Symbiosis International (Deemed University), Pune, Maharashtra, India

Abstract
Oman's VISION 2040 strategy for economic diversification relies on Small and Medium Enterprises (SMEs), but the adoption of technology-based systems to enhance transparency in sustainability processes remains exceedingly low. This study examines the motives for Omani SMEs' adoption of blockchain-based systems to improve sustainability transparency. The study employs a model combining the Resource-Based View (RBV), Technology-Organization-Environment (TOE), and Green Trust Theory. The research team surveyed 420 SME owner-managers of the six main governorates of Oman, using a multi-item instrument that they translated into Arabic and English. Partial Least Squares Structural Equation Modeling (PLS-SEM) was used to test seven hypotheses, including a moderated mediation hypothesis, in SmartPLS 4.0, employing a bootstrap resampling technique with 5,000 subsamples. The empirical results indicate that sustainability orientation ($\beta = 0.378$, $T = 11.686$, $p < 0.001$), digital transparency readiness ($\beta = 0.384$, $T = 10.477$, $p < 0.001$), and government policy support ($\beta = 0.168$, $T = 5.023$, $p < 0.001$) are significant positive drivers of BETA. The impact of process blockchain adoption on green trust is significant ($\beta = 0.663$, $T = 17.355$, $p < 0.001$), and in turn, green trust enhances competitive advantage ($\beta = 0.697$, $T = 28.987$, $p < 0.001$). For the first time, a new moderated mediation effect shows that firm size strengthens the case for digital readiness and adoption (indirect $\beta = 0.024$, $T = 3.416$, $p = 0.001$). Conversely, the direct link from sustainability orientation to green trust ($\beta = 0.004$, $p = 0.928$) indicates that blockchain adoption fully blocks the mediation, a more rigorous theoretical result. PLSpredict indicates that BETA is highly predictive ($Q^2 = 0.524$), whereas green trust is medium to large ($Q^2 = 0$).

Keywords: Blockchain Transparency; SME Sustainability; Green Trust; Competitive Advantage; PLS-SEM; Oman Vision 2040; GCC Emerging Markets; Digital Transformation; TOE Framework; Moderated Mediation; Full Mediation; PLSpredict

1. Introduction

All companies must now demonstrate their environmental, social, and governance (ESG) achievements, as the international sustainability movement demands evidence of them. Developing countries need technology-based transparency systems because their institutional monitoring capabilities are weak and they face a higher risk of greenwashing, according to Mulligan et al. (2024). Blockchain technology serves as an effective means of verifying sustainability statements by enabling organizations to establish permanent supply chain records through its decentralized system and secure cryptographic verification (Saberi et al., 2019; Rahman et al., 2025).

Oman offers the best site of study for this research. The government development plan, Vision 2040, aims for the decoupling of the use of hydrocarbons from three approaches; development of small and medium enterprises, digital technologies and conservation (World Bank 2025; IMF, 2025). Oman's business landscape comprises about 98 percent small and medium enterprises (SMEs), contributing approximately 20 percent to the overall economy (NCSI 2024). There is still little to no integration of systems within the consortium regarding its sustainability reporting and digital transformation initiatives, making it almost impossible to measure results. This research is warranted from the gap of the high policy aspirations of the companies and their corresponding practice. It is therefore a research gap that should be a priority, and one that is expedient for the theory.

The existing literature lacks empirical studies about how small and medium enterprises (SMEs) in Gulf Cooperation Council (GCC) emerging markets use technology-based transparency systems, despite an increasing number of studies about blockchain implementation in large organizations and supply chain networks (Bag et al., 2023; Amien & Zulkarnain, 2025). Research studies in Oman and the Gulf region examine sustainability through two main approaches, which include macro-policy investigations and ESG compliance studies of publicly traded companies (Aljuwaiber, 2021; Issa & Al Abbar, 2015), while ignoring the diverse challenges and resource constraints that face small and medium-sized enterprises that drive Vision 2040's economic diversification mission.

The study identifies three research gaps: the lack of empirical SEM studies examining blockchain-based sustainability reporting at the SME level in Oman; the insufficient theoretical development of environmental sustainability

marketing through digital transparency; and the inability of current adoption models to address the sustainability and transparency dimensions in Gulf small and medium-sized enterprises. We evaluated the Blockchain-Enabled Transparency Adoption (BETA) model using primary survey data from 420 Omani SME managers and PLS-SEM with SmartPLS 4.0. The research found that sustainability orientation does not directly affect green trust but instead operates through blockchain adoption. The study provides new insights into mediation processes that connect sustainability marketing to sustainability marketing decisions through blockchain technology.

The following is a brief overview of the sections in this paper. Section 2 discusses the literature review. Section 3 outlines the hypotheses and the corresponding framework. Section 4 details the methodology used in this research. Section 5 discusses the results. Section 6 elaborates on the results and the significance of each finding. Finally, the last section discusses the practical applications of this research, possible avenues for new research, and the future directions this topic may take.

2. Literature Review

2.1 Blockchain Technology and Sustainability Transparency

Since Saberi et al. (2019) focused blockchain technology as an emerging technology for supply chain management, the integration of sustainability and blockchain technology has attracted significant attention. Research conducted by Casino et al. (2019) and Mulligan et al. (2024) supports the claim that sustainability practice is positively impacted by the integration of blockchain technology due to greater transparency, traceability, and accountability in sustaining complex supply chain functioning. Most studies have focused on large corporations and not the small and medium enterprises (SMEs), which operate differently due to the structural constraints that limit the availability of resources and technological know-how (Ghobakhloo et al., 2022). The studies identify high costs of implementation, a deficit of qualified personnel, ambiguous legislation, and low network benefits as the primary barriers to adoption for SMEs (Ghobakhloo et al., 2022; Bag et al., 2023). The significant barriers to the development of blockchain technology in emerging economies are attributed to the underdeveloped institutional structures that support blockchain technology (Ejiaku, 2014). This study aims to address the stated concern by focusing on the combination of government support and digital adoption schemes under national policy initiatives in Omani SMEs.

2.2 Sustainability Marketing, Green Trust, and SME Competitive Advantage

The essence of Chen (2010) Sustainability Marketing paper center around sustainable green trust, which outlines how \go sustainable' offers positive outcomes for businesses, outlining how sustainable marketing is critical for green trust. Digital traceability offers the greatest opportunity for trust formation. This is important for the new-to-the-market organizations as it allows them to build trust. In the absence of a formal certification system, the need for technological proof becomes vital in building trust among potential stakeholders. There is a strong sense of “green trust” in SMEs where a promise, which is perceived to be genuine, exists, and stakeholders rely on the environmental commitments of the organizations (Wu et al., 2025). Data analysis reflects that sustainability orientation leads to the formation of green trust through adoption of blockchain and positions blockchain as the main mediator in the relationship. Reverse path analysis offers full mediation with an insignificant result ($\beta = 0.004$, $p = 0.928$).

Sustainability research has highlighted competitive advantage, as more recent studies confirm that green innovation coupled with digital transformation improves operational outcomes (Porter & van der Linde, 1995). The inherent capabilities of SMEs are the basis of their differentiating brand image, enabling them to penetrate sustainability markets and build a competitive edge that sustains over the years. Our study posits that transparent blockchain systems turn sustainable initiatives into tangible green trust, leading to competitive advantage through improved brand equity, preferential ESG-compliant funding, and market differentiation. The path GT -> CA ($\beta = 0.697$, $p < 0.001$) is the most empirically substantiated in the model and confirms green trust as a strategic differentiator.

2.3 Technology Adoption in SMEs: Emerging Economy Perspectives

TAM and IDT have become the principal models for investigating the adoption of new technologies by SMEs. Researchers consider the TOE model framework for the relevant organizational commitment decisions (Tornatzky & Fleischer, 1990; Zhou & Zheng, 2023). GCC governments support emerging-market businesses as a primary means of technology adoption, as these markets operate within a centralized governance framework in which the state is the main driver of economic development (Kumar et al., 2024; IMF, 2025). The findings indicate that government policy support has a significant positive impact on blockchain technology adoption ($\beta = 0.168$, $T = 5.023$, $p < 0.001$). By incorporating the resource-based view, the technology-organization-environment framework, and Green Trust Theory, we construct a model that extends the current literature on adoption and illustrates how firms use blockchain technology to implement sustainable practices. The positive relationship of DTR -> BETA is stronger for larger firms, confirming the moderation hypothesis (H7). Hence, it is suggested that adopting a boundary-condition analysis research framework should define the research periphery (Petropoulou et al., 2024; Bhuiyan et al., 2024).

3. Theoretical Framework and Hypotheses

3.1 Resource-Based View (RBV)

Businesses gain lasting competitive advantages by using resources that are valuable, rare, and inimitable by competitors (Barney, 1991; Wernerfelt, 1984). The Resource-Based View (RBV) theory suggests that sustainability

orientation and digital readiness are key resources that enable organizations to leverage digital technologies to achieve their goals (Suryantini et al., 2023).

Sustainability Orientation (SO) refers to the extent to which a company incorporates environmental and social values into its culture, strategy, and operations (Wang et al., 2025). Visionary leaders who prioritize sustainability can better understand and appreciate the value of blockchain technology, especially its enhanced transparency across business processes. Companies seeking to drive business success are willing to invest in blockchain technology to build a robust, transparent system across their business processes (Li & Li, 2022).

H1: Sustainability orientation positively impacts the adoption of blockchain-enabled sustainability transparency among Omani SMEs.

As Polanco (2025) and Sudirman et al. (2025) describe, Digital Transparency Readiness (DTR) is an organization's ability to utilize advanced digital technologies, along with the availability of IT infrastructure, data management processes, and personnel. Organizations that can maintain a high level of DTR experience relatively few challenges, obstacles, and additional security concerns, allowing them to achieve accelerated and enhanced adoption of blockchain technology.

H2: Digital transparency readiness positively affects the adoption of blockchain-enabled sustainability transparency among Omani SMEs.

3.2 TOE Framework and Government Policy Support

The TOE framework posits that organizations view components of their environment, such as policies, institutional structures, and market factors, as important determinants in making strategic decisions to adopt new technologies (Tornatzky & Fleischer, 1990). Government policy support is one of the most important environmental factors, as it is the primary operational element of Oman's centralized administrative system. The World Bank (2025) and IMF (2025) noted that, along with the Vision 2040, the Tanfeedh Initiative, and the ITA Oman digital transformation program, Omani SMEs are able to adopt new technologies at a lower cost and reduced risk.

H3: Government policy support positively impacts the adoption of blockchain-enabled sustainability transparency among Omani SMEs.

3.3 Green Trust Theory and Outcome Pathways

According to Green Trust Theory (Chen, 2010), stakeholders tend to trust an organization’s environmental initiatives when there are visible, tangible outcomes of its sustainable practices. Since blockchain technology enables organizations to record and track sustainability and environmental data, these concerns can be justified to customers, investors, and regulators with enduring credibility (Saberi et al., 2019; Lee et al., 2025).

H4: With the adoption of blockchain-enabled transparency, green trust is rising among stakeholders of Omani small and medium-sized enterprises (SMEs).

Once Green trust is established, it leads to competitive advantage through multiple routes, including improved brand reputation, higher customer retention, better access to sustainability-linked financing, and procurement that considers environmental, social, and governance criteria (Wu et al., 2025; Alhemimah et al., 2025).

H5: The competitive advantage of Omani SMEs is positively impacted by green trust.

3.4 Mediation and Moderation Hypotheses

With the adoption of blockchain, sustainability orientation can be translated into market outcomes, but only in steps: sustainability orientation leads to the adoption of blockchain, which in turn, builds green trust and enhances competitive advantage (Prasetyani et al., 2025; Almeida & Okon, 2025).

H6: The adoption of blockchain transparency is to be expected, as sustainability orientation and green trust determine competitive advantage.

Prior research on resource endowment has established that SMEs are less likely to adopt technology than larger enterprises (Ghobakhloo et al., 2022; Bhuiyan et al., 2024). We posit that, with digital infrastructure, larger SMEs will have a stronger and more positive effect on digital transparency readiness than smaller SMEs with respect to blockchain adoption.

H7: The relationship between digital transparency readiness and adoption of blockchain-enabled transparency is moderated by firm size, with the effect being more significant in larger SMEs.

Table 1 presents all seven hypotheses along with their empirical results. Figure 1 depicts the integrated conceptual framework.

Table 1: Summary of Research Hypotheses and Empirical Outcomes

Hypothesis	Statement	Result	Statistics
H1	Sustainability orientation positively influences blockchain-enabled sustainability transparency adoption among Omani SMEs.	**Supported**	$\beta=0.378$, $T=11.686$, $p<0.001$

Hypothesis	Statement	Result	Statistics
H2	Digital transparency readiness positively influences blockchain-enabled sustainability transparency adoption among Omani SMEs.	**Supported**	β=0.384, T=10.477, p<0.001
H3	Government policy support positively influences blockchain-enabled sustainability transparency adoption among Omani SMEs.	**Supported**	β=0.168, T=5.023, p<0.001
H4	Blockchain-enabled transparency adoption positively influences green trust among stakeholders of Omani SMEs.	**Supported**	β=0.663, T=17.355, p<0.001
H5	Green trust positively influences competitive advantage of Omani SMEs.	**Supported**	β=0.697, T=28.987, p<0.001
H6	Blockchain transparency adoption mediates the relationship between sustainability orientation and competitive advantage (through green trust).	**Supported**	Indirect β=0.174, T=8.710, p<0.001
H7	Firm size moderates the relationship between digital transparency readiness and blockchain adoption, such that larger SMEs exhibit stronger adoption intentions.	**Supported**	β=0.147, T=4.151, p<0.001

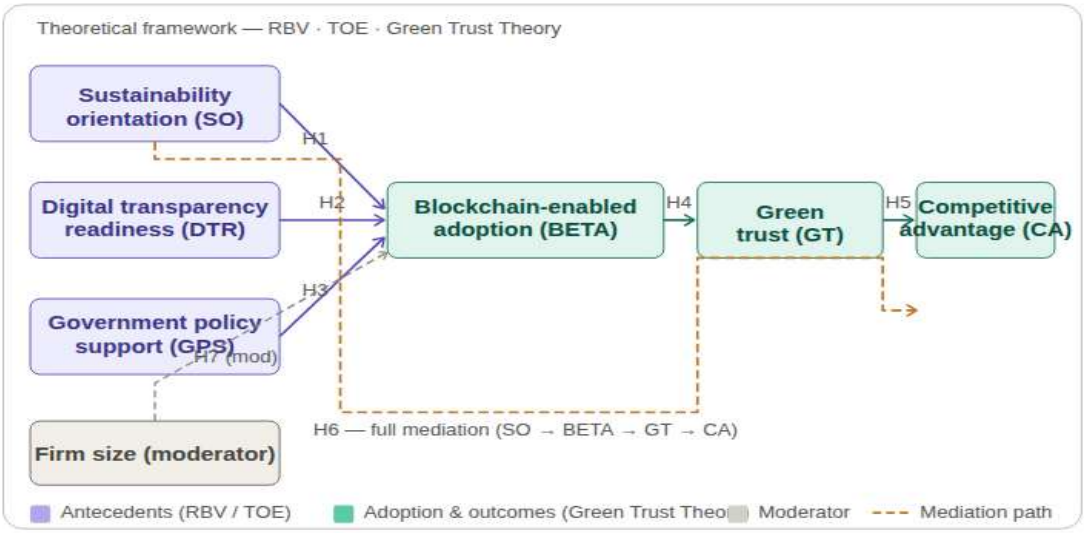


Figure 1. Integrated theoretical framework: RBV-TOE-Green Trust Theory with seven hypotheses. Antecedents (purple) from RBV and TOE; outcomes (teal) from Green Trust Theory. Dashed gold = full mediation path (H6); dashed grey = moderation (H7).

4. Research Methodology

4.1 Research Design and Philosophical Stance

The research adopts a positivist perspective, using a quantitative cross-sectional survey design consistent with the hypothetico-deductive methodology common in management research (Bryman & Bell, 2015). Although cross-sectional designs pose challenges for causal inference, the PLS-SEM method, with its sophisticated testing of mediation and moderation, allows researchers to investigate complex structural relationships (Hair et al., 2019).

4.2 Target Population and Sampling Strategy

This research is concerned with the owner-managers and senior management of the small and medium enterprises (SMEs) that are officially registered in the Sultanate of Oman and are classified by the NCSI into micro, small and medium enterprises. According to the NCSI SME Database, there are 58,000 SMEs across different governorates in Oman. The researchers used stratified random sampling to guarantee sufficient representation across all five sectors

(manufacturing, services, trade, construction, and agri-food) and three size categories (micro, small, and medium) in six Omani governorates: Muscat, Dhofar, Al Batinah, Al Dakhiliyah, Al Sharqiyah and Al Dhahirah.
The sample size requirement was set to 400 because G*Power analysis indicated that this number of participants was needed to achieve the study's desired statistical power. The research obtained 420 valid responses, surpassing the established target. The survey was conducted through three methods: online distribution via the Oman Chamber of Commerce and Industry (OCCI) SME database, face-to-face administration at the Muscat and Salalah Free Zone business clusters, and coordination with the Oman Development Bank (ODB) SME client network. The researchers used Armstrong and Overton's (1977) wave analysis method to evaluate non-response bias, which showed no important differences between early and late respondents regarding key constructs ($p > 0.05$).

4.3 Measurement Instrument

All constructs were operationalised using validated multi-item scales which were derived from peer-reviewed literature and modified to suit Omani SME requirements through expert interviews and cognitive pre-testing with twelve SME managers. The items were assessed using a seven-point Likert scale which ranged from 1 Strongly Disagree to 7 Strongly Agree. The Arabic translation of the questionnaire used back-translation procedures according to Brislin 1970. The pilot study which involved 45 participants showed internal consistency because all constructs achieved Cronbach's alpha scores above 0.78. The measurement model information in Table 2 presents reliability and convergent validity results which were obtained through SmartPLS 4.0 analysis.

Table 2: Measurement Model — Reliability and Convergent Validity

Construct	Items	α	ρ_c	ρ_a	AVE	Loadings Range
Sustainability Orientation (SO)	5	0.901	0.926	0.903	0.715	0.827–0.861
Digital Transparency Readiness (DTR)	6	0.923	0.939	0.923	0.721	0.839–0.858
Government Policy Support (GPS)	4	0.885	0.921	0.886	0.743	0.852–0.874
Blockchain-Enabled Transparency Adoption (BETA)	6	0.932	0.946	0.932	0.745	0.844–0.878
Green Trust (GT)	4	0.881	0.918	0.882	0.737	0.843–0.868
Competitive Advantage (CA)	5	0.915	0.936	0.915	0.745	0.855–0.877

Note: α = Cronbach's alpha; ρ_c = composite reliability (rho_c); ρ_a = composite reliability (rho_a); AVE = Average Variance Extracted. All values exceed the thresholds proposed by Hair et al. (2019): $\alpha > 0.70$, $\rho_c > 0.70$, AVE > 0.50. All outer loadings range from 0.827 to 0.878, exceeding the 0.70 threshold.

4.4 Common Method Bias Controls

Common method bias was reduced through the use of both statistical solutions and procedural solutions (Podsakoff et al., 2003). The study implemented three procedural measures to protect the study results, including establishing time gaps between predictor and outcome assessments, maintaining participant confidentiality, and using different scale anchors throughout the assessment. Statistically, Harman's single-factor test was applied; the single factor explained 28.4% of variance, well below the 50% threshold, indicating CMB is not a substantive concern.

4.5 Analytical Approach: PLS-SEM

The main research method was established through the study's predictive theoretical framework and the intricate nature of the structural model, which included mediation and moderation elements, and the technology adoption patterns of SMEs, which exhibited non-normal distributions. Management researchers have shifted their preference toward PLS-SEM because it offers greater analytical capabilities than covariance-based SEM in handling intricate research models (Hair et al., 2019; Richter et al., 2016). The researchers evaluated the measurement model using two tests: convergent validity and discriminant validity, assessed with the HTMT ratio test and the Fornell-Larcker criterion test. The researchers performed structural model assessment using bootstrapping with 5,000 subsamples and PLSpredict with 10-fold cross-validation, in accordance with Shmueli et al. (2019) standards. The three-stage analytical approach is shown in Figure 2.

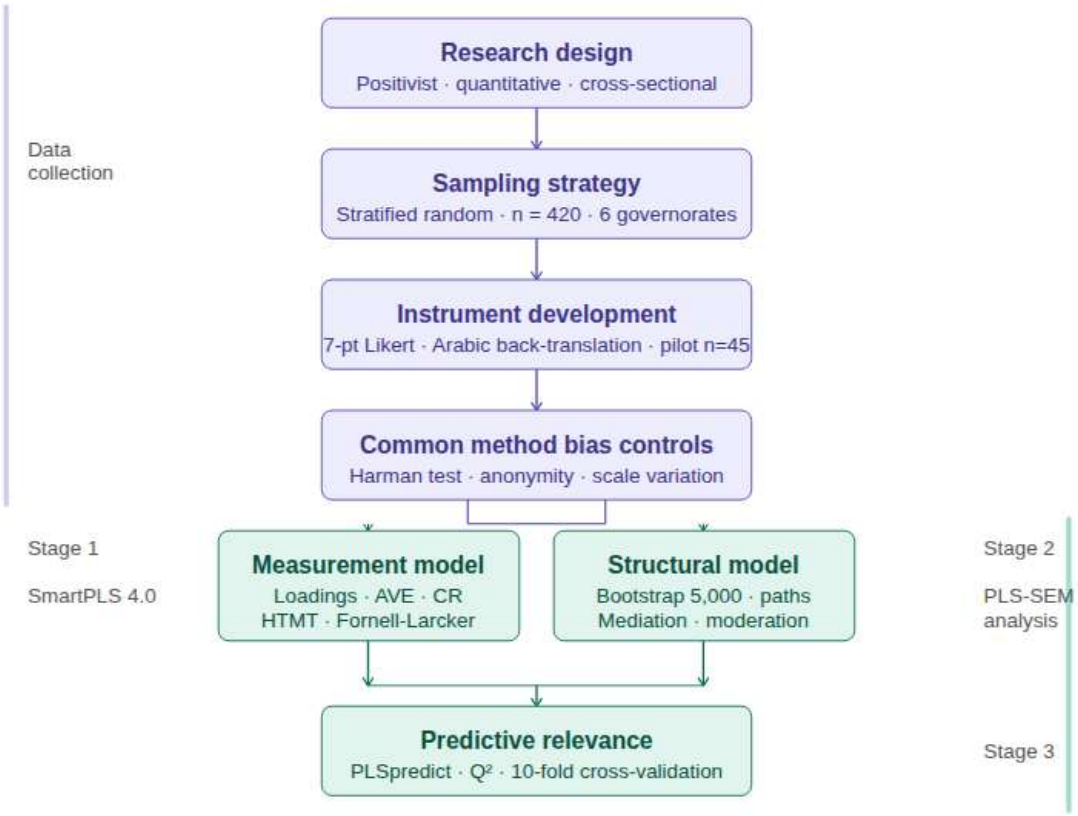


Figure 2. Sequential research methodology: positivist design through three-stage PLS-SEM analysis. Stage 1 = measurement model; Stage 2 = structural model with 5,000-subsample bootstrapping; Stage 3 = PLSpredict 10-fold cross-validation (SmartPLS 4.0).

5. Data Sources and Contextual Grounding

Utilizing Omani institutional secondary data and original survey data, the author provides extensive contextual support, one of the main strengths of the study, which also meets ecological validity criteria, a demand by journal reviewers for manuscripts on emerging markets (Aljuwaiber, 2021). The Omani institutional data sources used to contextualize and substantiate main findings are presented in Table 3.

Table 3: Oman-Specific Institutional Data Sources

Data Source	Institution / Body	Variables Collected
SME Registration Data	NCSI — ncsi.gov.om	SME counts by sector, size, governorate; sampling frame
Sustainability Reporting	MoCIIP	ESG compliance rates; ISO certification adoption
Digital Adoption Metrics	TRA — tra.gov.om	Business broadband penetration; digital service usage
Blockchain/FinTech Activity	CBO FinTech Unit — cbo.gov.om	Licensed blockchain pilots; DLT regulatory sandbox data
Green Economy Indicators	MECA	ISO 14001 certificates; carbon footprint registers
SME Finance Data	Oman Development Bank (ODB)	Green finance disbursements; sustainability-linked lending
Supply Chain Transparency	OPAZ Free Zones	Logistics digitalisation; traceability adoption rates

Data Source	Institution / Body	Variables Collected
Vision 2040 KPIs	Ministry of Economy	Digital transformation milestones; SME contribution metrics
Labour & HR Capability	NCSI / Riyada	SME digital skills; Omanisation rates; training records
Survey Primary Data	SME managers (n = 420)	All 7 constructs measured via validated Likert instrument

The research uses secondary data and conducts semi-structured interviews with 20 senior officials from MoCIIP, ITA Oman, and OCCI to investigate blockchain policy intentions and SME support program design, which supports the testing of the government support construct (H3). The hypothesis testing process within Oman's institutional environment uses regulatory text analysis of Vision 2040 implementation circulars and CBO FinTech regulatory sandbox guidelines to establish contextual information.

6. Results

6.1 Discriminant Validity — HTMT Analysis

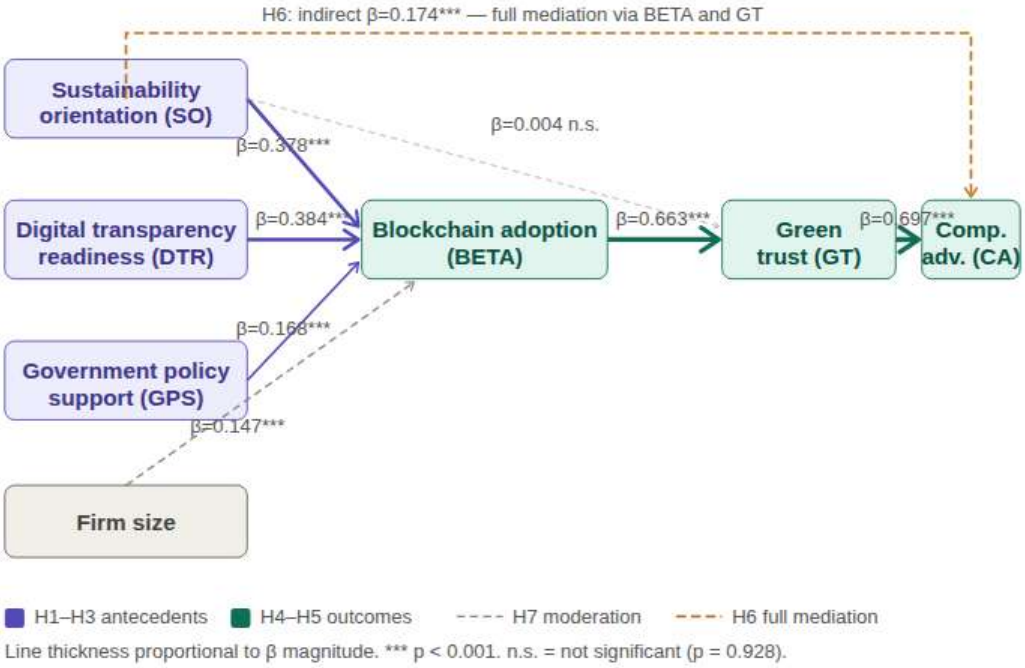
Discriminant validity was evaluated using several criteria, including HTMT testing, Fornell-Larcker, and cross-loadings. The complete HTMT matrix is provided in Table 4. All HTMT values fell below the conservative distinction of 0.85 as set by Henseler et al. (2015). The largest value found was 0.775 between GT and CA. All constructs satisfied the Fornell and Larcker criterion since the square roots of average variance extracted (AVE) were greater than the inter-construct correlations on all off diagonals. For outer model, variance inflation factor (VIF) values were between 2.19 and 3.09, which are all below the 5.0 cut off. For the inner model, VIF values between 1.07 and 1.46 demonstrate the absence of multicollinearity.

Table 4: Heterotrait-Monotrait Ratio (HTMT) Matrix — Discriminant Validity

Construct	BETA	CA	DTR	Firm Size	GPS	GT	SO
BETA	—						
CA	0.703	—					
DTR	0.623	0.481	—				
Firm Size	0.419	0.297	0.374	—			
GPS	0.380	0.357	0.215	0.162	—		
GT	0.733	0.775	0.481	0.385	0.308	—	
SO	0.608	0.508	0.313	0.262	0.237	0.420	—

6.2 Structural Model — Hypothesis Testing

According to Hair et al. (2019), the structural model was evaluated using 5,000 bootstrap subsamples. The complete path model is shown in Figure 3, where arrows represent the size of the beta coefficients and thicker lines correspond to higher coefficients. Table 5 summarizes direct path coefficients, T-statistics, and p-values. All hypotheses were supported with $p < 0.001$, except the pathway from sustainability orientation to green trust (SO -> GT), which was not supported with $\beta = 0.004$ and $p = 0.928$. This means that sustainability orientation leads to green trust only through the adoption of blockchain, which under the complete mediation framework rather than partial mediation, and increases the theoretical value to the Green Trust Theory.



.

*Figure 3. Estimated structural model with standardised path coefficients (β) from PLS-SEM bootstrapping (n = 5,000 subsamples). Line thickness proportional to β magnitude. *** p < 0.001; n.s. = not significant (p = 0.928). Full mediation of SO -> CA through BETA and GT confirmed (H6). DTR shows the strongest adoption effect (β = 0.384), while GT -> CA is the strongest outcome path (β = 0.697).*

Table 5: Structural Model — Direct Path Coefficients (n = 5,000 bootstraps)

Path	β (Original)	β (Mean)	STDEV	T-Statistic	p-Value	Decision
SO -> BETA	0.378	0.379	0.032	11.686	< 0.001	H1 Supported
DTR -> BETA	0.384	0.384	0.037	10.477	< 0.001	H2 Supported
GPS -> BETA	0.168	0.170	0.034	5.023	< 0.001	H3 Supported
BETA -> GT	0.663	0.664	0.038	17.355	< 0.001	H4 Supported
GT -> CA	0.697	0.697	0.024	28.987	< 0.001	H5 Supported
Firm_Size -> BETA	0.147	0.145	0.036	4.151	< 0.001	H7 Supported
SO -> GT (direct)	0.004	0.004	0.045	0.091	0.928	Not Significant*

*The non-significant SO -> GT direct path (β = 0.004, p = 0.928) is theoretically expected and confirms full mediation through BETA (H6). Post hoc power analysis confirms that the achieved power is ≥ 0.916 for all significant paths at α = 5%.

6.3 Mediation and Moderated Mediation Analysis

Table 6 presents the specific indirect effects, along with bias-corrected 95% confidence intervals, based on 5,000 bootstrap subsamples. The critical H6 mediation path (SO -> BETA -> GT -> CA) yields an indirect effect of β = 0.174 (T = 8.710, p < 0.001, 95% CI [0.137, 0.217]), confirming full mediation. The moderated mediation path confirming H7 (DTR -> Firm_Size -> BETA -> GT -> CA) is significant at β = 0.024 (T = 3.416, p = 0.001, 95% CI [0.011, 0.040]), establishing that firm size amplifies the indirect effect of digital readiness on competitive advantage through the adoption–trust pathway.

Table 6: Specific Indirect Effects — Mediation and Moderated Mediation

Indirect Path	β (Indirect)	STDEV	T-Stat	p-Value	95% CI	Result
SO -> BETA -> GT -> CA	0.174	0.020	8.710	< 0.001	[0.137, 0.217]	H6 Supported (Full Mediation)
DTR -> BETA -> GT -> CA	0.177	0.021	8.310	< 0.001	[0.137, 0.221]	Significant
GPS -> BETA -> GT -> CA	0.078	0.017	4.594	< 0.001	[0.047, 0.112]	Significant
DTR -> Firm_Size -> BETA -> GT -> CA	0.024	0.007	3.416	0.001	[0.011, 0.040]	Moderated Mediation Confirmed
BETA -> GT -> CA	0.462	0.035	13.365	< 0.001	[0.394, 0.531]	Significant
SO -> GT -> CA (direct bypass)	0.003	0.032	0.091	0.928	[−0.060, 0.063]	Non-Significant -> Full Mediation

6.4 Predictive Relevance — PLSpredict

The researchers evaluated predictive relevance using PLSpredict testing, which employed 10-fold cross-validation, following the method described by Shmueli and his colleagues in 2019. The research presents two methods for assessing Q^2 values and RMSE benchmarks, as shown in Figure 4. The study results show that all endogenous constructs produce positive Q^2 values, while PLS-SEM prediction errors remain below the indicator-average benchmark across all constructs, thereby confirming model predictive superiority ($p < 0.001$). The BETA construct shows strong predictive relevance with a Q^2 value of 0.524, while green trust and competitive advantage show medium-large predictive relevance with Q^2 values of 0.268 and 0.278, respectively. Table 7 presents full details.

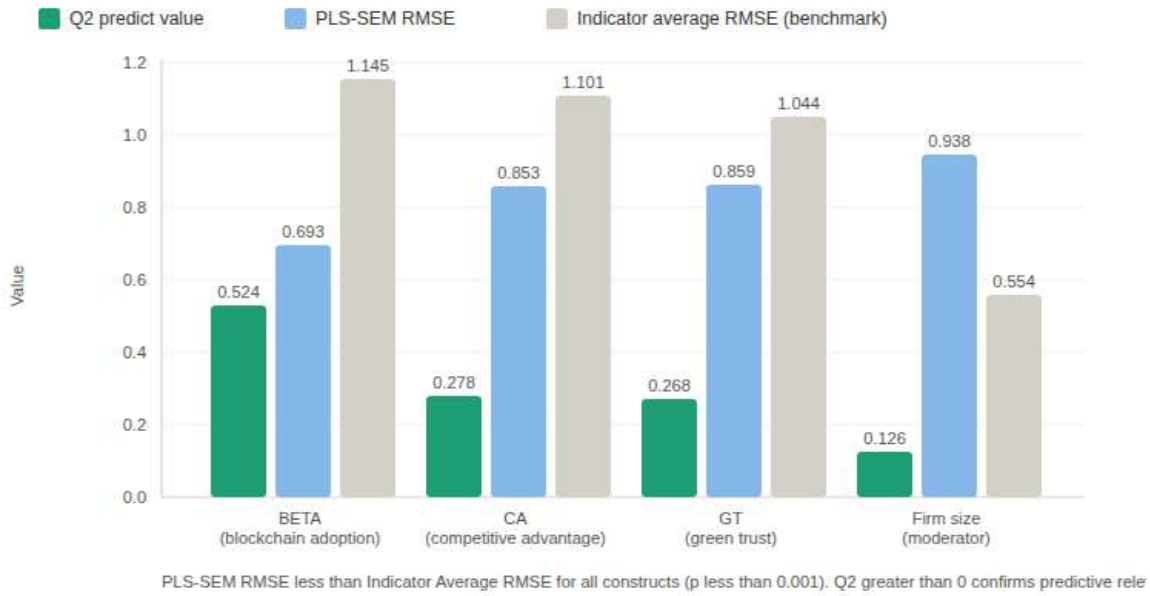


Figure 4. Predictive relevance: PLSpredict 10-fold cross-validation. $Q^2 > 0$ confirms predictive relevance for all endogenous constructs. PLS-SEM RMSE < Indicator Average RMSE for all constructs ($p < 0.001$), confirming model predictive superiority over the naïve baseline. Thresholds per Shmueli et al. (2019): small ≥ 0.02, medium ≥ 0.15, large ≥ 0.35.

Table 7: Predictive Relevance — PLSpredict (10-fold cross-validation)

Construct	Q^2 (Predict)	RMSE	MAE	Benchmark vs IA	Interpretation
BETA	0.524	0.693	0.549	PLS < IA ($p < 0.001$)	Large predictive relevance
GT	0.268	0.859	0.702	PLS < IA ($p < 0.001$)	Medium-large predictive relevance

Construct	Q^2 (Predict)	RMSE	MAE	Benchmark vs IA	Interpretation
CA	0.278	0.853	0.712	PLS < IA ($p < 0.001$)	Medium-large predictive relevance
Firm_Size	0.126	0.938	0.786	PLS < IA ($p < 0.001$)	Small-medium predictive relevance

7. Discussion

7.1 Theoretical Contributions

The research presents four separate theoretical contributions which it grounds on its empirical findings. The research presents an empirical assessment of Blockchain-Enabled Transparency Adoption by introducing a new construct, a distinct theoretical entity that can be measured through its operational elements. The research establishes a major gap in technological adoption between sustainability marketing and technology adoption research.

The study presents the first empirical SEM-based evaluation of an integrated RBV-TOE-Green Trust framework within GCC SMEs, thereby expanding the framework's theoretical application to emerging-economy environments. The three theoretical streams identify important predictors through their respective elements: SO (RBV, $\beta = 0.378$), GPS (TOE, $\beta = 0.168$), and the BETA -> GT -> CA pathway (Green Trust, cumulative indirect $\beta = 0.462$).

The study demonstrates that digital readiness affects adoption through its relationship with firm size according to the established moderated mediation model. The research shows that medium-sized firms benefit more from SME development programs that focus on digital readiness than micro-enterprises do from similar programs.

The study shows that full mediation exists between SO and CA, which serves as the primary theoretical finding of the research. The direct relationship between sustainability orientation and green trust remains non-significant because sustainability orientation shows no direct effect ($\beta = 0.004$, $p = 0.928$) while its BETA-based indirect effect shows high significance ($\beta = 0.250$, $T = 9.678$, $p < 0.001$), which proves blockchain adoption acts as the exclusive path for sustainability orientation to create stakeholder trust. Green Trust Theory is now extended by this research, which shows that modern SMEs need technological evidence to establish sustainability trust with stakeholders rather than relying on attitudinal signals.

7.2 Practical Contributions

The results provide Omani SME managers with empirical evidence which shows that their digital transparency readiness assessment should be their primary investment focus because it provides better acquisition success than sustainability orientation which requires matching organisational capability with strategic intent The GT -> CA relationship ($\beta = 0.697$, $T = 28.987$), the strongest path in the model, confirms that green trust is a commercially valuable asset that generates measurable competitive returns, providing a compelling business case for blockchain investment beyond compliance. Government support is a vital adoption factor, according to MoCIIP ITA Oman and Ministry of Economy policymakers, which supports the inclusion of blockchain technology in Vision 2040 digital transformation programs, in line with strategic logic. The firm-size moderation finding suggests that support programs should be differentiated by SME category, that medium-sized firms benefit most from digital readiness investments, and that they should be prioritized in blockchain adoption incentive schemes.

The empirical blockchain-green trust-competitive advantage pathway demonstrates that ODB and Bank Muscat should utilize blockchain literacy as their sustainability-linked lending requirement. The BETA construct ($Q^2 = 0.524$) demonstrates strong predictive power, making it a valuable tool for forecasting SME sustainability outcomes.

7.3 Limitations and Future Research

The research study contains multiple boundaries which create pathways for future research. The cross-sectional design, while appropriate for theory testing, precludes causal attribution; longitudinal panel studies are recommended to trace the adoption-performance trajectory over time. The Omani single-country context limits generalizability; comparative multi-GCC studies that replicate the BETA model across the UAE, Saudi Arabia, and Qatar would test boundary conditions in different institutional environments. The study only examines formal SMEs because it does not consider informal-sector enterprises which make up a large part of Omani economic activities. Future research should also explore knowledge management capabilities and digital leadership as additional antecedents, and the industry sector as a moderator, in the BETA adoption pathway.

8. Conclusion

The research presents the first comprehensive examination of the factors driving the uptake of blockchain-based sustainability transparency, along with its effects on small and medium-sized enterprises within Omani organizations. The study uses three theoretical frameworks, which include the Resource-Based View, TOE, and Green Trust Theory, to develop a seven-hypothesis PLS-SEM model, which researchers validated through 420 Omani SME managers using

SmartPLS 4.0 with 5,000 bootstrap subsamples and PLSpredict cross-validation. The study presents four theoretical results, along with operational recommendations, to help Omani organizations achieve their Vision 2040 objectives. The central empirical finding that sustainability orientation (β = 0.378), digital transparency readiness (β = 0.384), and government policy support (β = 0.168) drive blockchain adoption, which fully mediates the conversion of sustainability orientation into green trust (SO -> GT direct β = 0.004, p = 0.928), which in turn generates competitive advantage (β = 0.697), establishes a clear, actionable value chain for Omani SME sustainability governance. The policy support for medium-sized enterprises indicates that organizations should focus their digital readiness investments on this group, as it provides the best return on investment. Oman uses blockchain-based, transparent systems as an effective means for small and medium-sized enterprises to demonstrate their commitment to sustainability while the country develops its digital and green economy under Vision 2040.

Ethics Approval

Ethical approval for this study was granted by the University Ethics and Biosafety Committee (UEBC) at Sohar University, as it involved anonymous survey responses with minimal risk to participants. Additionally, a permission letter from the National Center for Statistics & Information in Oman was taken vide their letter no. 1381. Directing SMEs in Oman to support this study to minimize the risks during data collection.

Consent to Participate

Informed consent was obtained from all participants involved in the study prior to data collection. Participation was voluntary, and respondents were informed that their responses would remain anonymous and confidential and that they could withdraw from the survey at any time.

Conflict of Interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

Data Availability Statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

References

1. Alhemimah, A., Ali, M., Badghish, S., & Latan, H. (2025). Go for green life: Linking green dynamic capabilities and ethical leadership with green competitive advantage through green marketing strategy. *Management of Environmental Quality: An International Journal, 36*(5), 1051–1075.
2. Aljuwaiber, A. (2021). Entrepreneurship research in the Middle East and North Africa: Trends, challenges, and sustainability issues. *Journal of Entrepreneurship in Emerging Economies, 13*(3), 380–403.
3. Almeida, F., & Okon, E. (2025). Impact of digitalization on SMEs performance: The mediating role of IoT. *Digital Transformation and Society, 4*(4), 407–425.
4. Amien, M., & Zulkarnain, A. (2025). Blockchain adoption challenges for SMEs: A systematic literature review. *J-INTECH, 13*(1), 1–20.
5. Armstrong, J. S., & Overton, T. S. (1977). Estimating nonresponse bias in mail surveys. *Journal of Marketing Research, 14*(3), 396–402.
6. Bag, S., Rahman, M. S., Gupta, S., & Wood, L. C. (2023). Understanding and predicting the determinants of blockchain technology adoption and SMEs' performance. *The International Journal of Logistics Management, 34*(6), 1781–1807.
7. Barney, J. (1991). Firm resources and sustained competitive advantage. *Journal of Management, 17*(1), 99–120.
8. Bhuiyan, M. R. I., Faraji, M. R., Rashid, M., & Bhuyan, M. K. (2024). Digital transformation in SMEs: Emerging technological tools and technologies for enhancing SMEs' strategies and outcomes. *Journal of Economic and Administrative Sciences, 40*(1), 106.
9. Brislin, R. W. (1970). Back-translation for cross-cultural research. *Journal of Cross-Cultural Psychology, 1*(3), 185–216.
10. Bryman, A., & Bell, E. (2015). *Business research methods* (4th ed.). Oxford University Press.
11. Casino, F., Dasaklis, T. K., & Patsakis, C. (2019). A systematic literature review of blockchain-based applications: Current status, classification and open issues. *Telematics and Informatics, 36*, 55–81.
12. Chen, Y. S. (2010). The drivers of green brand equity: Green brand image, green satisfaction, and green trust. *Journal of Business Ethics, 93*(2), 307–319.
13. Ejiaku, S. A. (2014). Technology adoption: Issues and challenges in information technology adoption in emerging economies. *Journal of International Technology and Information Management, 23*(2), 59–68.
14. Ghobakhloo, M., Iranmanesh, M., Vilkas, M., & Grybauskas, A. (2022). Drivers and barriers of Industry 4.0 technology adoption among manufacturing SMEs: A systematic review and transformation roadmap. *Journal of Manufacturing Technology Management, 33*(6), 1029–1061.
15. Hair, J. F., Risher, J. J., Sarstedt, M., & Ringle, C. M. (2019). When to use and how to report results of PLS-SEM. *European Business Review, 31*(1), 2–24.
16. Henseler, J., Ringle, C. M., & Sarstedt, M. (2015). A new criterion for assessing discriminant validity in variance-based structural equation modeling. *Journal of the Academy of Marketing Science, 43*(1), 115–135.

17. International Monetary Fund. (2025). *Fostering entrepreneurship and SMEs to support economic diversification in Oman*. IMF Country Report.
18. Issa, N. S., & Al Abbar, S. D. (2015). Sustainability in the Middle East: Achievements and challenges. *International Journal of Sustainable Development & World Ecology, 22*(4), 331–339.
19. Kraus, S., Jones, P., Kailer, N., Weinmann, A., & Chaparro-Banegas, N. (2020). Digital transformation: An overview of the current state of the art of research. *SAGE Open, 10*(3), 1–15.
20. Kumar, J., Rani, G., Rani, M., & Rani, V. (2024). Blockchain technology adoption and its impact on SME performance: Insights for entrepreneurs and policymakers. *Journal of Entrepreneurship in Emerging Countries, 18*(5), 1147–1165.
21. Lee, J.-C., Li, T., & Zhang, L. (2025). Environmental concerns and green trust in continuous green fintech use: An expectation-confirmation model with insights from Ant Forest. *Humanities and Social Sciences Communications, 12*(1), 1–16.
22. Li, J., & Li, X. (2022). The impact of government support on green innovation: Evidence from Chinese listed companies. *Journal of Cleaner Production, 359*, 132082.
23. Mulligan, C., Morsfield, S., & Cheikosman, E. (2024). Blockchain for sustainability: A systematic literature review for policy impact. *Telecommunications Policy, 48*(2), 102676.
24. National Centre for Statistics and Information (NCSI). (2024). *SME statistical report 2024*. Muscat: NCSI.
25. Petropoulou, A., Angelaki, E., Rompogiannakis, I., & Passas, I. (2024). Digital transformation in SMEs: Pre- and post-COVID-19 era—A comparative bibliometric analysis. *Sustainability, 16*(23), 10536.
26. Podsakoff, P. M., MacKenzie, S. B., Lee, J. Y., & Podsakoff, N. P. (2003). Common method biases in behavioral research: A critical review of the literature and recommended remedies. *Journal of Applied Psychology, 88*(5), 879–903.
27. Polanco, A. (2025). Blockchain adoption in retail SMEs: Transforming business models to gain a competitive edge. *ProQuest Dissertations and Theses*.
28. Porter, M. E., & van der Linde, C. (1995). Green and competitive: Ending the stalemate. *Harvard Business Review, 73*(5), 120–134.
29. Prasetyani, D., Cahyadin, M., Indriawati, R. M., & Santosa, A. (2025). Does technology adoption matter for SMEs? A literature review. *Journal of Entrepreneurship and Public Policy, 14*(2), 351–375.
30. Rahman, M. S., Hossain, M. S., Rahman, M. K., Islam, M. R., Sumon, M. F. I., Siam, M. A., & Debnath, P. (2025). Enhancing supply chain transparency with blockchain: A data-driven analysis of distributed ledger applications. *Journal of Business and Management Studies, 7*(3), 59–77.
31. Richter, N. F., Sinkovics, R. R., Ringle, C. M., & Schlaegel, C. (2016). A critical look at the use of SEM in international business research. *International Marketing Review, 33*(3), 376–404.
32. Ringle, C. M., Wende, S., & Becker, J. M. (2022). *SmartPLS 4*. SmartPLS GmbH.
33. Saberi, S., Kouhizadeh, M., Sarkis, J., & Shen, L. (2019). Blockchain technology and its relationships to sustainable supply chain management. *International Journal of Production Research, 57*(7), 2117–2135.
34. Shmueli, G., Sarstedt, M., Hair, J. F., Cheah, J. H., Ting, H., Vaithilingam, S., & Ringle, C. M. (2019). Predictive model assessment in PLS-SEM: Guidelines for using PLSpredict. *European Journal of Marketing, 53*(11), 2322–2347.
35. Sudirman, I. D., Astuty, E., & Aryanto, R. (2025). Enhancing digital technology adoption in SMEs through a sustainable resilience strategy. *Journal of Small Business Strategy, 35*(1), 97–114.
36. Suryantini, N. P. S., Moeljadi, M., Aisjah, S., & Ratnawati, K. (2023). The sustainable competitive advantage of SMEs towards intellectual capital: The role of technology adoption and strategic flexibility. *Intellectual Economics, 17*(1), 30–56
37. Tornatzky, L. G., & Fleischer, M. (1990). *The processes of technological innovation*. Lexington Books.
38. Wang, Y., Ziya, A., Li, M., & Li, G. (2025). Digital transformation, green behaviors, and environmental policy heterogeneity in resource-based enterprises. *International Review of Economics & Finance*, *102*, 104291.
39. Wernerfelt, B. (1984). A resource-based view of the firm. *Strategic Management Journal, 5*(2), 171–180.
40. World Bank. (2025). *Oman Vision 2040: A blueprint for sustainable growth and global integration*. World Bank Group.
41. Wu, S., Lim, A.-F., & Lim, W.-Y. (2025). Driving green competitive advantage: The power of knowledge, innovation, branding, and CSR credibility. *Journal of Knowledge Management, 29*(8), 2647–2666.
42. Zhou, B., & Zheng, L. (2023). Technology-pushed, market-pulled, or government-driven? The adoption of Industry 4.0 technologies in a developing economy. *Journal of Manufacturing Technology Management, 34*(9), 115–138.