ISSN 2409-2665
Journal of Logistics, Informatics and Service Science
Vol. 13 (2026) No. 8, pp. 41-54
DOI:10.33168/JLISS.2026.0803

Knowledge-Based Structural Transformation and Sustainable Upgrading in Oman: A Decision-Analytics Approach Using Entropy-Weighted TOPSIS

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Abstract. Knowledge-based structural transformation in resource-dependent economies is a multidimensional process shaped by the joint evolution of productive sophistication, competitiveness, sustainability performance, and external capital integration. This study develops an entropy-weighted Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) framework to evaluate sustainable upgrading in Oman. Annual observations for 1990–2024 are treated as decision alternatives and assessed using six criteria: green total factor productivity (GTFP), research-based economic complexity, technology-based economic complexity, trade-based economic complexity, foreign direct investment (FDI), and the Global Competitiveness Index (GCI). The results indicate a clear long-run strengthening of Oman's multidimensional transformation profile, with the strongest performance concentrated in the mid-2010s and sustained strength in the early 2020s. The highest-ranked year is 2015, whereas 1991 is the weakest observation. Entropy weights show that research-based complexity provides the greatest discriminatory power across years, followed by FDI, GTFP, and competitiveness. A robustness check based on equal-weight TOPSIS confirms that the ranking structure is highly stable under alternative weighting assumptions. The study contributes a transparent decision-support framework for evaluating structural upgrading over time and shows that Oman's future progress depends on stronger alignment among green productivity, capability-enhancing investment, competitiveness reform, and research-linked diversification.

Keywords: decision analytics; entropy-weighted TOPSIS; structural transformation; sustainable upgrading; economic complexity; Oman; competitiveness; green total factor productivity

1. Introduction

Structural transformation is increasingly understood as a multidimensional development process in which productivity upgrading, capability accumulation, institutional competitiveness, and external integration evolve jointly rather than independently (Andreoni et al., 2021; Fu et al., 2021). Innovation capability, for example, is better viewed as a systemic construct that combines inputs, outputs, and enabling conditions rather than as a single proxy such as patents or R&D expenditure (Saunila, 2016; Saunila & Ukko, 2013). In parallel, the economic complexity literature argues that development depends not merely on output expansion but on the deepening of productive sophistication and the accumulation of embedded capabilities, including capabilities needed for green diversification (Ajide, 2022; Mealy & Teytelboym, 2022). Trade-based evidence from the renewable energy sector likewise suggests that upgrading is reflected not only in volume expansion but also in the structure and direction of cross-border exchange (Khudari et al., 2026a).

For Oman, these issues are especially salient. As a resource-based economy pursuing long-run diversification, the challenge is not only to expand non-oil activity, but also to strengthen the deeper capability structures that support more sophisticated, resilient, competitive, and sustainable growth. This perspective is consistent with Oman Vision 2040, which frames national development in terms of diversification, knowledge, innovation, competitiveness, and sustainability rather than as isolated policy goals (Oman Vision 2040, 2023). Oman-focused scholarship likewise shows that governance quality, environmental adjustment, and productivity-enhancing external integration are important to this transition, reinforcing the view that institutional reform, capability deepening, and sustainable upgrading should be treated as analytically connected dimensions of development rather than as separate domains (Al-Saadi & Khudari, 2024; Al-Hajri & Khudari, 2025; Khudari et al., 2026a). In this setting, green total factor productivity (GTFP) captures the quality dimension of economic performance under sustainability considerations. The economic complexity indicators capture distinct channels of productive sophistication, foreign direct investment (FDI) reflects external capital and knowledge integration, and the Global Competitiveness Index (GCI) reflects the broader institutional and market environment within which upgrading occurs.

The analytical problem is that these dimensions are often studied separately. Innovation and competitiveness studies typically emphasise institutional and performance systems, complexity studies focus on productive sophistication, and FDI studies examine capital inflows and spillovers. In practice, however, structural upgrading depends on how these dimensions reinforce one another. An economy may improve competitiveness without materially deepening productive sophistication, attract FDI without embedding domestic capability, or record productivity gains without achieving broader structural upgrading.

This is also a methodological problem. Once transformation is treated as inherently multidimensional, single-indicator assessment becomes inadequate. Multi-criteria decision analysis (MCDA), therefore, offers a more appropriate framework, and TOPSIS is particularly suitable because it ranks alternatives according to their proximity to an ideal profile and their distance from a negative profile. In addition, MCDA research emphasises the importance of transparent weighting procedures and robustness checks so that substantive conclusions do not depend on arbitrary weighting assumptions.

Against this background, the present study develops an annual TOPSIS-based assessment of Oman using six indicators: GTFP, ECI_Research, ECI_Technology, ECI_Trade, FDI (% of GDP), and GCI. Conceptually, these indicators are treated as complementary manifestations of knowledge-based structural transformation. GTFP captures productivity quality; the three economic complexity measures capture productive sophistication through distinct capability channels; FDI captures external integration and potential knowledge inflows; and GCI captures the competitive environment that enables or constrains upgrading.

The study addresses four research questions. First, how can Oman's structural transformation be assessed through an integrated annual framework that combines productivity quality, complexity, investment, and competitiveness? Second, what does a TOPSIS-based time-series assessment reveal about Oman's best-performing and weakest-performing years? Third, which dimensions contribute most strongly to annual differentiation in Oman's transformation profile? Fourth, are the ranking results robust to alternative weighting assumptions?

To answer these questions, the study pursues four objectives. First, it constructs a multi-criteria annual evaluation model for Oman. Second, it applies entropy-weighted TOPSIS to rank yearly performance. Third, it identifies the relative salience of each indicator through entropy weights. Fourth, it evaluates robustness by comparing entropy-weighted and equal-weight specifications.

The remainder of the manuscript is organised as follows. Section 2 reviews the relevant literature and develops the hypotheses. Section 3 presents the methodology, indicator design, weighting procedure, and TOPSIS model. Section 4 reports and discusses the empirical results. Section 5 concludes and outlines the policy implications.

2. Literature Review and Hypotheses Development

2.1. Structural transformation as capability-based upgrading

Structural transformation is increasingly understood as a process of capability-based upgrading rather than as a simple shift in sectoral output shares. The central issue is not only whether an economy expands production, but whether it develops the knowledge, institutional support, and organisational depth required to sustain more sophisticated, resilient, and sustainable forms of economic activity. In this perspective, innovation capability is better treated as a system of inputs, outputs, linkages, and enabling conditions than as a single observable proxy. Economies do not upgrade merely by spending more, attracting more investment, or producing more in isolation; they upgrade when knowledge generation, diffusion, and application reinforce one another through institutional and market structures (Chen et al., 2020; Al-Ajmi et al., 2026).

This systemic perspective is especially relevant to resource-based economies. In such settings, long-run transformation depends not only on diversification away from resource dependence but also on the creation of deeper capability structures that support technological learning, adaptation, and sustained productivity improvement. For Oman, this issue is particularly salient because the national development agenda explicitly emphasises diversification, knowledge, innovation, competitiveness, and sustainability as mutually reinforcing pillars of future development rather than as separate policy domains (Oman Vision 2040, 2023).

2.2. Economic complexity, green diversification, and productive sophistication

The economic complexity literature sharpens the capability-based view of development by arguing that prosperity depends on what an economy can produce, how sophisticated those activities are, and how deeply the required know-how is embedded in the productive system. Complexity is therefore commonly interpreted as an indirect measure of accumulated productive knowledge and capability depth. Hidalgo and Hausmann (2009) provide the foundational argument that development reflects not only specialisation, but the diversity and exclusivity of the productive capabilities an economy possesses. Ajide (2022) extends this logic by showing that economic complexity is linked to entrepreneurial dynamism, suggesting that productive sophistication can support broader capability formation.

The relevance of complexity becomes stronger when development is considered jointly with sustainability. Mealy and Teytelboym (2022) show that countries diversify more readily into green activities that are related to capabilities they already possess. Neagu (2021) likewise argues that economic complexity has become an important environmental challenge because productive structures shape both development opportunities and environmental pressures. Canh and Thanh (2020) further show that, in emerging economies, complexity also has environmental consequences, which strengthens the case for evaluating productive sophistication and sustainability together rather than separately. In this view, productive sophistication is not a static trade attribute; it is a dynamic expression of deeper developmental capacity.

For a resource-based economy such as Oman, this has direct analytical relevance. Transformation cannot be adequately captured by output expansion alone. It must also be assessed in terms of whether the economy is developing research-linked, technology-linked, and trade-linked capability structures that support greener and more sophisticated forms of production. The use of multidimensional economic complexity indicators is therefore appropriate because each captures a distinct channel of productive sophistication.

2.3. Competitiveness and the enabling environment of upgrading

Competitiveness research adds a further dimension by showing that productive sophistication is more likely to translate into stronger developmental outcomes where the broader institutional and market environment supports knowledge exchange, entrepreneurship, and participation in value networks. Competitiveness is not merely a background condition. It is part of the mechanism through which productive capabilities are translated into higher-value economic performance. Wang and Turkina (2020), for example, show that economic complexity, global connectivity, and competitiveness are closely connected in shaping sustainable development outcomes.

This linkage is especially important for Oman because competitiveness reform is not separable from the diversification strategy. Governance quality, regulatory effectiveness, institutional coordination, and the broader business environment help determine whether productive capability can be deepened and whether new sectors can scale. Oman-focused evidence similarly indicates that governance quality and institutional effectiveness are closely linked to growth performance, supporting the view that competitiveness reform and capability building should be treated as analytically connected rather than independent agendas (Al-Saadi & Khudari, 2024).

2.4. Foreign direct investment and external knowledge integration

FDI occupies an important place in the structural transformation literature because it can provide finance, managerial expertise, technology transfer, and integration into broader production systems. Its developmental effects, however, are not automatic. The contribution of FDI depends on domestic absorptive capacity, institutional quality, and the extent to which foreign capital becomes embedded in local upgrading processes rather than remaining weakly connected to domestic capability formation.

Recent evidence suggests that FDI can also contribute to greener productivity and structural upgrading when it facilitates technological spillovers and more efficient production systems. Yu et al. (2021) show that the spatial agglomeration of FDI can improve green total factor productivity, while Zhao et al. (2022) likewise identify positive channels through which foreign investment supports urban GTFP. These findings strengthen the interpretation of FDI as more than a capital-flow variable. Under favourable institutional and absorptive conditions, it can operate as a conduit for learning, greener production practices, and industrial upgrading. This logic is also broadly consistent with Oman-related evidence linking FDI and external integration to sustainable upgrading and productivity improvement (Khudari et al., 2023; Khudari et al., 2026a).

2.5. Green total factor productivity as the quality dimension of transformation

The inclusion of GTFP reflects a further refinement in development analysis. Structural transformation should not be judged only by output expansion or sectoral diversification, but also by the quality and sustainability of productivity improvement. In a resource-based economy, this is crucial because diversification that does not improve efficiency, environmental performance, or capability depth cannot be treated as sustainable upgrading in a strong sense.

A growing empirical literature shows that GTFP is shaped by a broader capability and finance architecture. Li and Liao (2020) show that financial development has a heterogeneous effect on GTFP.

Lee and Lee (2022) find that green finance significantly improves green productivity. Cheng et al. (2023) report that digital financial inclusion promotes GTFP through innovation and entrepreneurship channels. Hu and Li (2023) further show that financial technology development contributes to green productivity improvement. Chen et al. (2023) demonstrate that green technological innovation, green finance, and financial development jointly influence GTFP outcomes. Taken together, this literature suggests that GTFP should not be treated as a narrow environmental performance indicator. Rather, it is a system-level measure of whether productive transformation is becoming cleaner, more efficient, and more knowledge-intensive.

This broader argument is also relevant to Oman. Recent Oman-focused work suggests that environmental adjustment, growth quality, competitiveness, and sustainability are closely connected and should not be treated as separate policy agendas (Al-Hajri & Khudari, 2025; Khudari et al., 2026a). In the present study, GTFP is therefore positioned as the productivity-quality dimension of sustainable upgrading.

2.6. Integrated framework, decision-analytics logic, and hypotheses

Taken together, the literature suggests that Oman's structural transformation is best assessed through an integrated framework rather than a single-indicator approach. The economic complexity dimensions capture productive sophistication through different capability channels, competitiveness captures the enabling institutional and market environment, FDI captures external capital and knowledge integration, and GTFP captures the quality and sustainability of productivity improvement. These dimensions should therefore be treated as complementary rather than substitutable. Productive sophistication alone does not guarantee strong developmental outcomes unless it is supported by a competitiveness environment that enables knowledge diffusion and upgrading, while FDI does not necessarily improve structural performance unless it becomes linked to domestic capability formation and productivity enhancement. Likewise, improvements in green productivity are more meaningful when they are embedded in broader processes of capability deepening, institutional support, and external integration. This interpretation is consistent with research linking complexity to competitiveness and sustainable development, with evidence that FDI can contribute to greener productivity through spillover and agglomeration channels, and with work showing that GTFP is shaped by broader finance-, innovation-, and institutional conditions rather than by one isolated factor alone (Wang & Turkina, 2020; Yu et al., 2021; Lee & Lee, 2022; Mealy & Teytelboym, 2022).

From a methodological standpoint, this integrative logic also supports the decision-analytics design of the study. Once transformation is treated as inherently multidimensional, a multi-criteria decision analysis framework becomes more appropriate than a single-variable assessment. MCDA has been widely used to evaluate complex sustainability problems involving interdependent criteria, and TOPSIS remains one of the most established ranking methods because it evaluates alternatives according to their distance from ideal and anti-ideal profiles (Hwang & Yoon, 1981; Hwang et al., 1993). This multidimensional logic is also consistent with more recent MCDA scholarship emphasizing transparent evaluation across several indicators of capability and sustainability rather than dependence on one proxy alone (Lohman et al., 2023). Entropy-based weighting further strengthens transparency by assigning weights according to information dispersion across alternatives, consistent with the information-theoretic logic introduced by Shannon (1948). Prior methodological work also supports the use of entropy-weighted TOPSIS as a practical and robust approach for multi-criteria ranking problems (Zanakis et al., 1998; Dehdasht et al., 2020; Elma et al., 2024).

Based on the foregoing literature, the study advances the following hypotheses:

H1. Oman's annual structural transformation performance improved over the sample period.

H2. Economic complexity dimensions are positively associated with stronger annual transformation performance.

H3. Higher FDI and stronger competitiveness are associated with higher annual transformation performance.

H4. The ranking structure remains robust under alternative weighting assumptions.

3. Research Design and Methodology

This study adopts a longitudinal MCDA design in which each year constitutes an alternative to be evaluated. The annual decision matrix is constructed using six indicators for Oman: GTFP, ECI_Research, ECI_Technology, ECI_Trade, FDI (% of GDP), and GCI. These variables were selected because they jointly capture productivity quality, multidimensional productive sophistication, external capital attractiveness, and competitiveness conditions. Figure 1 summarises the analytical sequence and the study's expected empirical pattern.

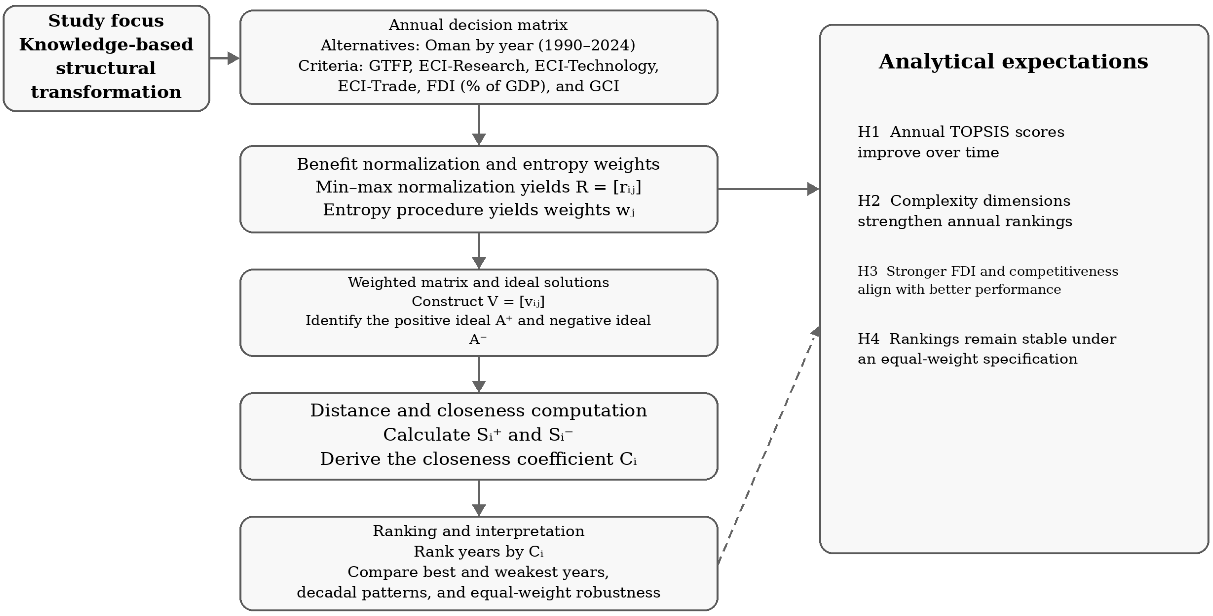

Fig.1: Conceptual framework of TOPSIS procedures and analytical expectations

Table 1. Indicators, definitions, and analytical role

Indicator	Operational meaning	Analytical role in the model	Criterion type	Main source of data
GTFP	Green total factor productivity	Productivity quality under environmental and sustainability constraints	Benefit	Author-compiled annual GTFP series based on the study's analytical dataset
ECI_Research	Research-based economic complexity	Research-linked capability accumulation and knowledge depth	Benefit	The Observatory of Economic Complexity (OEC) / complexity database
ECI_Technology	Technology-based economic complexity	Technology-linked sophistication and production capability	Benefit	The Observatory of Economic Complexity (OEC) / complexity database
ECI_Trade	Trade-based economic complexity	Trade-linked productive sophistication and export-related capability	Benefit	The Observatory of Economic Complexity (OEC) / complexity database
FDI (% GDP)	Foreign direct investment as % of GDP	External capital attraction and potential knowledge spillovers	Benefit	World Bank, World Development Indicators (WDI)

GCI	Global Competitiveness Index	Competitiveness environment and institutional-market readiness	Benefit	World Economic Forum (WEF), Global Competitiveness Reports

Annual observations for Oman covering 1990–2024 were compiled from explicitly identified sources. FDI (% of GDP) was obtained from the World Bank World Development Indicators (World Bank, 2026). The three economic complexity indicators, ECI_Research, ECI_Technology, and ECI_Trade, were obtained from The Observatory of Economic Complexity (n.d.). The competitiveness indicator was compiled from the World Economic Forum's *Global Competitiveness Report* source architecture and harmonised in the study's analytical dataset to construct a consistent annual competitiveness series for Oman (World Economic Forum, 2025). GTFP was constructed by the author using the Malmquist–Luenberger index, with GDP as the desirable output and CO_2 emissions as the undesirable output. The model, therefore, evaluates yearly changes in Oman's multidimensional transformation profile rather than causal effects across the criteria.

Table 2. Descriptive statistics of the decision criteria (1990–2024)

Indicator	Mean	Std. dev.	Minimum	Maximum
GTFP	0.9313	0.1821	0.6000	1.1850
ECI_Research	-0.6998	0.2815	-1.1424	-0.1960
ECI_Technology	-1.8908	0.6477	-3.0077	-0.4722
ECI_Trade	-0.5062	0.2410	-0.9574	-0.1548
FDI (% GDP)	2.6914	1.1974	0.5000	4.9000
GCI	4.1300	0.7515	2.8000	5.4500

Because the indicators differ in scale, they are first normalised. Given that higher values are preferred for all six variables in their operationalised form, benefit-type normalisation is applied. Entropy weighting is then used to determine indicator importance objectively from the annual data. The entropy procedure assigns higher weights to indicators that provide greater informational differentiation across years. This is appropriate in the present context because the study aims to reduce arbitrary subjective weighting and allow the data to indicate which variables matter most for annual discrimination.

Let x_{ij} denote the raw value of year i on indicator j. The normalized value z_{ij} is obtained through min–max scaling. The entropy proportion is then computed as:

$$p_{ij} = \frac{z_{ij}}{\sum_{i=1}^{m} z_{ij}}$$

where m is the number of annual observations. Indicator entropy is calculated as:

$$e_j = -k \sum_{i=1}^{m} p_{ij} \ln (p_{ij}), k = \frac{1}{\ln (m)}$$

The degree of diversification is:

$$d_j = 1 - e_j$$

and the corresponding entropy weight is:

$$w_j = \frac{d_j}{\sum_{j=1}^{n} d_j}$$

where n is the number of indicators.

After weighting, the TOPSIS procedure is implemented. The weighted normalised matrix is defined as:

$$v_{ij} = w_j z_{ij}$$

The positive ideal solution $\boldsymbol{A}^{+}$and a negative ideal solution $\boldsymbol{A}^{-}$are:

$$\boldsymbol{A}^{+} = \{\max_{i} (\boldsymbol{v}_{ij})\}$$
$$\boldsymbol{A}^{-} = \{\min_{i} (\boldsymbol{v}_{ij})\}$$

The Euclidean distances to the positive and negative ideals are:

$$\boldsymbol{D}_i^{+} = \sqrt{\sum_{j=1}^{n} (\boldsymbol{v}_{ij} - \boldsymbol{A}_j^{+})^2}$$

$$\boldsymbol{D}_i^{-} = \sqrt{\sum_{j=1}^{n} (\boldsymbol{v}_{ij} - \boldsymbol{A}_j^{-})^2}$$

The relative closeness coefficient is then calculated as:

$$\boldsymbol{C}_i = \frac{\boldsymbol{D}_i^{-}}{\boldsymbol{D}_i^{+} + \boldsymbol{D}_i^{-}}$$

A higher $\boldsymbol{C}_i$indicates that year $\boldsymbol{i}$is closer to the ideal transformation profile. Annual rankings are then produced by ordering $\boldsymbol{C}_i$from highest to lowest. To assess robustness, the entropy-weighted ranking is compared with an equal-weight TOPSIS ranking. This check is important because MCDA applications should remain substantively stable under plausible alternative weighting assumptions (Elma et al., 2024).

4. Results and Discussion

Tables 3 and 4 summarise the broad temporal pattern before the full annual ranking is presented in Table 5. The results reveal a marked long-run improvement in Oman's multidimensional transformation profile, moving from a weak early-1990s position to much stronger performance from the mid-2010s onward.

Table 3. Decadal averages of the entropy-weighted TOPSIS score

Period	Average entropy score
1990s	0.2003
2000s	0.4860
2010s	0.6881
2020–2024	0.7210

Note. The broad temporal profile shows a clear increase from the 1990s to the 2020–2024 period.

The decadal averages reinforce the same conclusion. The mean entropy-weighted score rises from 0.2003 in the 1990s to 0.4860 in the 2000s, then to 0.6881 in the 2010s and 0.7210 in 2020–2024. This pattern suggests cumulative rather than episodic upgrading, even though annual performance does not increase monotonically in every single year.

Table 4. Top and bottom five years by entropy-weighted TOPSIS score

Top rank	Top year	Top score	Bottom rank	Bottom year	Bottom score
1	2015	0.8218	35	1991	0.1388
2	2016	0.8073	34	1990	0.1460
3	2014	0.7775	33	1992	0.1516
4	2022	0.7664	32	1994	0.2040
5	2017	0.7450	31	1993	0.2108

Note. The concentration of top-ranked years in 2014–2017 and 2022 indicates that Oman's strongest performance was not a one-year anomaly.

Table 5 reports the full entropy-weighted annual ranking, and Figure 2 shows the composite time path. The strongest year is 2015, with a closeness coefficient of 0.8218, followed by 2016 (0.8073), 2014 (0.7775), 2022 (0.7664), and 2017 (0.7450). The weakest year is 1991 (0.1388), with 1990 and 1992 also among the lowest-ranked observations. The pattern is therefore highly asymmetric across time: the early 1990s form a distinctly weak block, whereas the mid-2010s and early 2020s represent the strongest phase.

Table 5. Annual entropy-weighted TOPSIS scores and rankings for Oman

Year	Entropy score	Rank	Year	Entropy score	Rank
1990	0.1460	34	**2007**	0.6254	13
1991	0.1388	35	**2008**	0.6487	12
1992	0.1516	33	**2009**	0.5940	16
1993	0.2108	31	**2010**	0.5791	17
1994	0.2040	32	**2011**	0.5704	18
1995	0.2139	30	**2012**	0.6196	14
1996	0.2181	29	**2013**	0.6022	15
1997	0.2293	28	**2014**	0.7775	3
1998	0.2356	27	**2015**	0.8218	1
1999	0.2545	26	**2016**	0.8073	2
2000	0.2933	25	**2017**	0.7450	5
2001	0.3138	24	**2018**	0.6791	10
2002	0.4130	23	**2019**	0.6787	11
2003	0.4650	22	**2020**	0.6913	9
2004	0.4790	20	**2021**	0.7340	6
2005	0.4662	21	**2022**	0.7664	4
2006	0.5620	19	**2023**	0.6954	8
			2024	0.7177	7

Note. Years are ranked from the largest closeness coefficient (best performance) to the smallest (weakest performance)

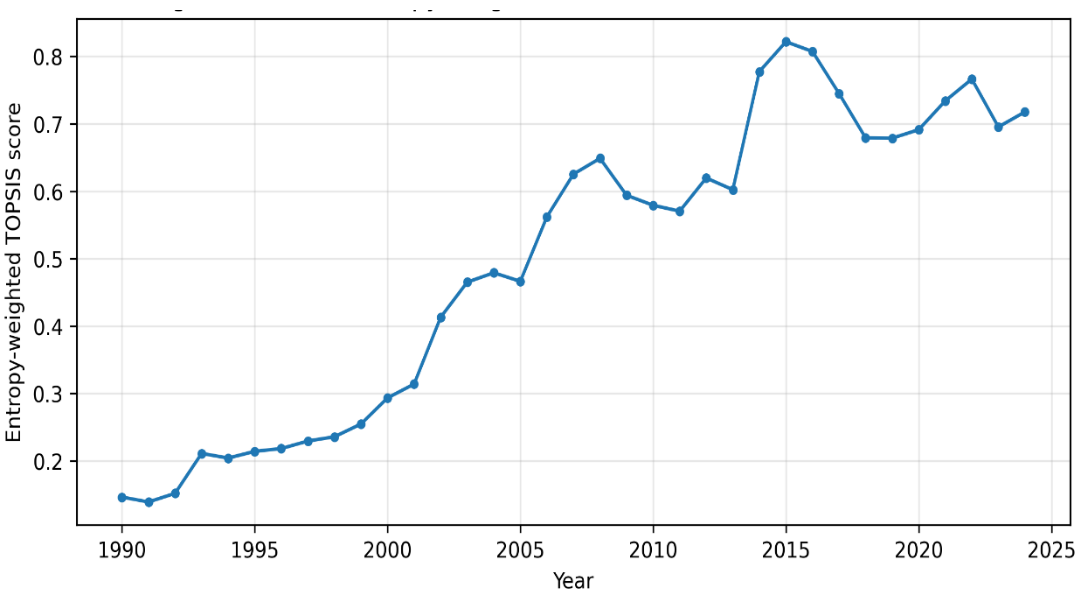

Fig.2: Annual entropy-weighted TOPSIS scores for Oman, 1990–2024

Table 6 reports the entropy weights. The most influential indicator is ECI_Research (0.2004), followed by FDI (% of GDP) (0.1684), GTFP (0.1659), GCI (0.1652), ECI_Technology (0.1520), and ECI_Trade (0.1480). This weighting pattern implies that research-linked complexity provides the greatest informational differentiation across years. Substantively, this suggests that Oman's transformation profile depends heavily on the research and capability dimension of complexity rather than on trade composition alone. This interpretation is consistent with the argument that green and knowledge-intensive diversification depends on deeper capability endowments, not merely on export presence by itself (Mealy & Teytelboym, 2022).

Table 6. Entropy values, diversification degrees, and indicator weights

Criterion	Entropy	Diversification	Weight
GTFP	0.9483	0.0517	0.1659
ECI_Research	0.9375	0.0625	0.2004
ECI_Technology	0.9526	0.0474	0.1520
ECI_Trade	0.9538	0.0462	0.1480
FDI (% GDP)	0.9475	0.0525	0.1684
GCI	0.9485	0.0515	0.1652

Note. Larger weights indicate greater discriminatory power across annual observations.

The top-ranked years suggest that Oman's strongest composite performance tended to coincide with relatively more balanced improvements across productivity quality, competitiveness, investment attraction, and productive sophistication. The leading years combine stronger GTFP, better competitiveness conditions, larger FDI inflows, and substantially less adverse complexity positions than those observed in the early part of the sample. By contrast, the weakest years display weak values across most major dimensions, indicating that Oman entered the sample period from a narrower capability base with more limited competitiveness and external integration. The broad temporal shift is therefore cumulative, but it should be interpreted carefully. The observed balance across dimensions is an inference from the composite ranking rather than a directly demonstrated causal result, and the TOPSIS framework should be understood as a benchmarking device for multidimensional performance rather than a causal identification strategy.

Table 7 presents the robustness comparison between the entropy-weighted and equal-weight rankings. The results are exceptionally stable. The rank correlation reaches 0.9992, the top-five overlap is 5/5, and the bottom-five overlap is 4/5. This stability is methodologically significant because it indicates that the ranking structure is not an artifact of one specific weighting scheme.

Table 7. Robustness comparison of entropy-weighted and equal-weight TOPSIS rankings

Metric	Value	Interpretation
Rank correlation	0.9992	Closer to 1 indicates stronger ranking agreement.
Top-5 overlap	5.0000	Years appearing in the top five under both methods.
Bottom-5 overlap	4.0000	Years appearing in the bottom five under both methods.

Overall, the empirical results support H1, H2, H3, and H4. Oman's annual transformation profile improves markedly over the sample period. The economic complexity dimensions, especially research-based complexity, contribute strongly to annual differentiation. FDI and competitiveness are closely aligned with higher-ranked years. Finally, the ranking structure remains highly stable under alternative weighting assumptions

5. Conclusion and Policy Implications

This study developed and applied an entropy-weighted TOPSIS framework to assess Oman's annual structural transformation using GTFP, ECI_Research, ECI_Technology, ECI_Trade, FDI (% of GDP), and GCI. The analysis shows that Oman moved from a persistently weak position in the early 1990s to a much stronger multidimensional profile after 2010, with the mid-2010s representing the strongest phase of performance. The highest-ranked year is 2015, while 1991 is the weakest observation in the series. These results indicate a substantial and cumulative strengthening of Oman's transformation profile over time, although the pattern should be interpreted as a composite benchmarking result rather than as evidence of causal effects among the indicators.

The central conclusion is that Oman's transformation has been multidimensional rather than reducible to a single channel of progress. Later high-ranking years are characterised by stronger competitiveness, higher FDI, improved green productivity, and less adverse complexity positions than those observed in the earlier part of the sample. At the same time, the entropy results show that research-related complexity carries the greatest discriminatory weight across years, which suggests that capability depth remains central to distinguishing stronger from weaker transformation outcomes. In this sense, Oman's future development depends not only on preserving recent gains but on deepening the knowledge base and productive capabilities that support more complex and more sustainable production.

The first policy implication is that Oman should prioritise research- and technology-linked capability building. Since research-based complexity carries the greatest informational weight in the annual ranking, stronger university–industry collaboration, technical skills development, commercialisation channels, and applied research capacity are likely to be central to sustaining long-run upgrading. This implication is also consistent with the broader green-complexity literature, which emphasises that successful transition into greener and more sophisticated activities depends on the capabilities an economy has already accumulated and on its ability to build related new ones (Mealy & Teytelboym, 2022; Neagu, 2021).

The second implication concerns the selective FDI strategy. The results suggest that FDI contributes meaningfully to stronger annual performance, but its developmental value depends on whether inflows enhance domestic capability, technological diffusion, and industrial upgrading rather than remaining weakly embedded. The wider literature supports this view: FDI is most beneficial when it contributes to productivity spillovers and greener upgrading rather than merely expanding capital inflows in accounting terms (Yu et al., 2021; Zhao et al., 2022). Oman should therefore target capability-enhancing FDI rather than volume alone, especially investment that strengthens technology absorption, learning effects, and green productivity spillovers.

The third implication is that competitiveness reform should be tied explicitly to complexity upgrading and sustainable productivity. Infrastructure, institutional quality, business facilitation, and logistics reform are most valuable when they support movement into more sophisticated and knowledge-intensive activities rather than being treated as separate policy silos. This aligns with Oman-related evidence that governance quality and knowledge-transfer mechanisms shape performance outcomes most effectively when institutional reform is coupled with capability development (Al-Saadi & Khudari, 2024; Al-Ajmi et al., 2026).

The fourth implication is that green productivity should be treated as a core upgrading channel. GTFP is not peripheral in the ranking structure; it is one of the central dimensions of Oman's stronger recent performance. Policies that support cleaner technologies, more efficient resource use, environmentally informed innovation, and productivity-enhancing financial mechanisms can therefore strengthen both sustainability and competitiveness. The broader literature suggests that green productivity can be reinforced through financial-development depth, green-finance instruments, digital financial inclusion, financial technology, and green technological innovation when these are linked to capability formation and cleaner production systems rather than treated as isolated policy tools (Li &

Liao, 2020; Lee & Lee, 2022; Cheng et al., 2023; Hu & Li, 2023; Chen et al., 2023). This also aligns with recent Oman evidence linking environmental adjustment, competitiveness conditions, and financial-development dynamics to greener productivity outcomes.

A final implication concerns monitoring and interpretation. The practical value of the TOPSIS framework is that it shows whether progress is relatively balanced across domains or concentrated in only one. This is analytically useful because strong performance in competitiveness or FDI alone does not guarantee deeper structural upgrading. At the same time, the findings should be read carefully: the result that Oman's strongest years were those with more balanced improvements across productivity quality, competitiveness, investment attraction, and productive sophistication is an inference from the ranking structure, not a directly estimated causal relationship. For this reason, the study is best understood as a transparent composite benchmarking exercise that can inform strategic monitoring and policy prioritization.

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