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Research Article

Provincial Development in Türkiye: A Composite Index Analysis of Çanakkale

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Abstract

Introduction: This study examines provincial development disparities in Türkiye through a structured assessment of Çanakkale's relative position within the national distribution. Motivated by persistent regional inequalities, the paper develops a clearer empirical hierarchy in which a PCA-based composite development index serves as the primary analytical tool, while clustering and comparative benchmarking are used for interpretation.

Method: Using cross-sectional data for 81 provinces in 2022, the study constructs a composite index from six indicators: per-capita production, start-ups per capita, investment per capita, agricultural production per capita, industrial share, and services share. Variables are standardised and aggregated through principal component analysis, and robustness is assessed through diagnostic tests and comparison with an equal-weight alternative. Provinces are then grouped into high-, medium-, and low-development typologies through k-means clustering, and Çanakkale is evaluated against national averages and a population-based peer group.

Results or Findings: The results show substantial interprovincial heterogeneity. Çanakkale ranks above the national mean and falls within the medium-development group. Its profile combines strong entrepreneurship and high investment per capita with moderate industrialisation and a relatively large agricultural base. This mixed structure helps explain why the province performs better than many peers but does not reach the high-development cluster.

Discussion or Conclusion: The findings suggest that Çanakkale represents a transitional development pattern and that stronger links between investment, entrepreneurship, and higher value-added industry are essential for upward movement.

Keywords: provincial development, composite development index, principal component analysis, structural transformation, Çanakkale Province

JEL Codes: R11, O18, C38, R58

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Türkiye’de İl Düzeyinde Kalkınma: Çanakkale’nin Bileşik Endeks Analizi

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Öz

Giriş: Bu çalışma, Türkiye’deki iller arası gelişmişlik farklılıklarını, Çanakkale’nin ulusal dağılım içindeki göreceli konumunu yapılandırılmış bir çerçevede incelemektedir. Süregelen bölgesel eşitsizliklerden hareketle, çalışmada temel analitik araç olarak PCA tabanlı bileşik gelişmişlik endeksi benimsenmiş; kümeleme ve karşılaştırmalı kıyaslamalar ise yorumlayıcı araçlar olarak kullanılmıştır.

Yöntem: Çalışmada 2022 yılına ait 81 ile ilişkin kesitsel veriler kullanılmıştır. Kişi başına üretim, kişi başına girişim sayısı, kişi başına yatırım, kişi başına tarımsal üretim, sanayi payı ve hizmetler payından oluşan altı göstergeyle bileşik bir endeks oluşturulmuştur. Değişkenler standartlaştırılmış, temel bileşenler analizi ile birleştirilmiş ve sağlamlık, tanısal testler ile eşit ağırlıklı alternatif bir endeksle karşılaştırma yoluyla değerlendirilmiştir. Ardından iller k-ortalamlar kümeleme yöntemiyle yüksek, orta ve düşük gelişmişlik tipolojilerine ayrılmış; Çanakkale hem ulusal ortalamlar hem de nüfus temelli akran il grubu ile karşılaştırılmıştır.

Sonuçlar ya da Bulgular: Bulgular, iller arasında belirgin bir heterojenliğe işaret etmektedir. Çanakkale ulusal ortalamanın üzerinde yer almakta ve orta gelişmişlik grubunda sınıflanmaktadır. İl, güçlü girişimcilik ve yüksek kişi başına yatırım ile orta düzey sanayileşme ve görece büyük bir tarımsal yapı bileşimini birlikte taşımaktadır. Bu karma yapı, ilin birçok akranından daha iyi performans göstermesine rağmen yüksek gelişmişlik kümesine ulaşamamasını açıklamaktadır.

Tartışma ya da Yapılan Çıkarımlar: Sonuçlar, Çanakkale’nin geçiş niteliği taşıyan bir gelişme örüntüsünü temsil ettiğini ve daha yüksek gelişmişlik düzeyine ilerleyebilmesi için yatırım, girişimcilik ve daha yüksek katma değerli sanayi arasındaki bağların güçlendirilmesi gerektiğini göstermektedir.

Anahtar Kelimeler: il kalkınması, bileşik kalkınma endeksi, temel bileşen analizi, yapısal dönüşüm, Çanakkale İli

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Introduction

Balanced regional development has become a major policy objective in Türkiye. Despite decades of growth, regional disparities remain pronounced, and provinces continue to display very different structures, capacities, and investment needs (Ekinci, 2025). These persistent gaps have intensified debate over how public resources can be allocated in ways that balance fairness and efficiency. The challenge is that provinces differ not only in economic size, but also in infrastructure, institutional capacity, service access, and the spatial distribution of opportunities and disadvantages (Çınar, 2023). Development trajectories are therefore shaped by multiple interacting dimensions rather than by income alone, making one-dimensional indicators insufficient for showing how places perform or where policy support is most needed (OECD, 2023; World Bank, 2009). This paper addresses that problem by constructing a composite development index for Türkiye's 81 provinces and using it to analyse structural transformation and relative performance, with particular attention to Çanakkale.

Structural transformation refers to the large-scale reallocation of labour and resources from low-productivity sectors such as agriculture to higher-productivity activities in industry and services. These shifts can generate important gains in aggregate productivity (Hamilton & de Vries, 2023). In Türkiye, major transformation followed the liberalisation reforms of the early 1980s, when production and exports moved away from agriculture toward industrial and service activities, improving competitiveness and integration into global markets. Yet these gains have been unevenly distributed across space. More than half of Türkiye's post-1980 growth has been driven by productivity improvements within sectors, while the contribution of intersectoral structural change has declined (Kaya & Çiçekçi, 2023). At the same time, high-productivity activities have become concentrated in metropolitan areas, leaving many peripheral provinces dependent on agriculture and low-wage services. This pattern suggests that policies focused only on productivity may deepen inequality unless they also address spatial equity (Ekinci, 2025).

Because regional development is multi-dimensional, it requires indicators that combine different types of information into a single measure. Composite indicators serve this purpose by aggregating several variables into an overall assessment. Methodological guidance stresses the importance of a clear theoretical framework, careful variable selection, and transparent weighting and aggregation rules (Nardo et al., 2005). Standardisation through z-scores places indicators on a common scale, although extreme values may still influence results. Other approaches, such as percentile ranking and sign reversal for undesirable indicators, have also been used in recent OECD dashboards (Seunga Ryu et al., 2024). In Türkiye, Ekinci (2025) used 109 indicators for 81 provinces and combined principal component analysis (PCA) with clustering algorithms to derive development profiles. While this demonstrates the value of data-driven classification, it also highlights the need for parsimonious and theoretically grounded indices. Existing studies often rely on ad hoc rankings or emphasise single dimensions such as income or infrastructure, and some blur the hierarchy of methods by presenting cluster results alongside composite scores without clarifying which method drives the central argument (Bulut & Öner, 2017; Gömleksiz et al., 2017).

In response, this study develops a transparent and theoretically grounded framework for assessing provincial development. It compiles a cross-sectional dataset for 2022 covering all 81 provinces and constructs a composite development index using six indicators: per-capita production value, start-ups per capita, investment per capita, agricultural production per capita, and the shares of industry and services in total production. Per-capita production reflects productive capacity, start-ups per capita capture entrepreneurial dynamism, and investment per

capita indicates capital deepening and future potential. Agricultural production per capita receives a negative loading in the PCA and helps identify provinces where dependence on primary production may signal a lower stage of structural transformation. The industry and services shares position provinces along the structural transformation continuum, with higher industrial shares generally associated with greater productivity and development.

The composite development index is placed at the centre of the analysis. After z-score standardisation, the six indicators are entered into PCA to extract the linear combination that captures the greatest share of common variance. Although the Kaiser-Meyer-Olkin statistic is low, the Bartlett test rejects the null of an identity correlation matrix, and the first component explains about one-third of total variance. This component is interpreted as the development index and rescaled to a $[0, 1]$ interval. A robustness check using an equal-weight index shows a high correlation with the PCA-based index, supporting the stability of the rankings. Descriptive comparisons and sectoral breakdowns are then used to interpret the index. K-means clustering is used only as a supplementary classification tool. Unlike factor analysis, which groups variables, k-means groups provinces by similarities across observations, minimising within-cluster differences and maximising between-cluster differences. The algorithm iteratively assigns provinces to the nearest centroid and updates cluster centres until no further reassignment occurs (Hartigan & Wong, 1979; Schreiber, 2021). In this study, $k = 3$ is used to derive high-, medium-, and low-development typologies, but these clusters are treated as interpretative aids rather than primary explanatory devices.

The results reveal marked heterogeneity in provincial development. The composite index ranges from 0 to 1, with a national mean of about 0.35. Zonguldak, Yalova, and Kocaeli rank highest, while Bitlis, Muş, and Kars rank lowest. Clustering identifies three broad typologies: high-development provinces with strong industrialisation and high investment, medium-development provinces with mixed structures and substantial services, and low-development provinces that remain largely agricultural with weak entrepreneurship and investment. Çanakkale records an index of about 0.416, placing it in the medium-development cluster. Its profile combines strong start-up density and considerable investment per capita with a large agricultural sector and an average industrial share, indicating a transitional economic structure. Comparisons with similarly populated provinces show that Çanakkale performs better in entrepreneurship and investment, but lags in per-capita production and industrial share. These findings underline the value of a multi-dimensional approach and caution against one-size-fits-all regional policies.

This study contributes in three ways. First, it provides a concise, transparent, and replicable provincial development index grounded in theory and supported by robustness checks. Second, it establishes a clear methodological hierarchy between the primary index, descriptive interpretation, and supplementary clustering. Third, by focusing on Çanakkale, it shows how the framework can diagnose the structural position of a specific province, highlighting both its strengths and its transitional character. The rest of the paper follows this structure: Section 2 reviews the literature, Section 3 explains the data and methodology, Section 4 presents the empirical results, and Section 5 concludes with policy implications and directions for future research.

Literature Review

This section reorganises the literature review around three strands that inform the empirical strategy: provincial development measurement, structural transformation and sectoral composition, and composite indicators and typologies.

Regional development measurement in Türkiye has long relied on composite indices that integrate multiple socio-economic variables. The influential Socio-Economic Development Index (SEGE) study by Dinçer et al. (2003) used principal component analysis (PCA) on 58 demographic, social, educational and productive indicators to rank all 81 provinces, demonstrating that provincial development is multidimensional and cannot be captured by income alone. Later SEGE updates employed robust PCA and emphasised selecting non-redundant social and economic indicators to ensure that rankings reflect true structural differences rather than noise. Beyond SEGE, researchers construct alternative indices and cluster analyses to explore provincial heterogeneity. Urfalıoğlu and Seyfullahoğulları (2004), Albayrak (2005) and Temurlenk and Abar (2019) apply multivariate methods to socio-economic indicators and report persistent east-west divides in Türkiye. Kılıç et al. (2011) use path analysis, hierarchical clustering and multidimensional scaling on 54 indicators to identify structural similarities and attribute regional disparities to differences in income distribution and investment. Similar index-based approaches in other countries, such as the Philippines and Eastern Uttar Pradesh, show that composite indices and clustering techniques are valuable tools for sub-national development analysis (Pede et al., 2012; Tanwar et al., 2016). Collectively, these studies justify the use of composite indicators and classification methods while underscoring the inherently multidimensional nature of development.

The second strand of literature examines structural transformation—the reallocation of economic activity across agriculture, industry and services—and its implications for regional development. The classical three-sector hypothesis posits that economies evolve from primary to secondary and then to tertiary dominance as productivity and demand patterns change. Fisher (1939) and later empirical work show that agriculture dominates in low-income economies, manufacturing expands during industrialisation and services become predominant at higher income levels. Van Neuss (2019) surveys drivers of structural change and identifies four determinants—income growth, relative sectoral prices, input-output linkages and trade-induced shifts in comparative advantage—that jointly explain how sectoral composition evolves across regions. Recent studies suggest that services often complement rather than substitute manufacturing. Using panel VAR and dynamic panel GMM models, Gaberli (2023) finds that expanding services sectors support rather than crowd out industry; this complementarity arises because producer services and manufacturing activities are interdependent. These insights imply that provincial differences in the balance of agriculture, industry and services can signal distinct stages of structural transformation, making sectoral composition a critical indicator of development stage and trajectory.

The third strand concerns composite indicators and typologies. Composite indices allow researchers to summarise diverse variables into a single measure but must be constructed with care. The OECD's Handbook on Constructing Composite Indicators stresses that correlation among indicators should not be mistaken for causality and that composite indices serve as descriptive synthesis tools rather than causal proofs. It recommends decomposing indices to understand the contributions of individual dimensions and warns against double counting or masking poor performance. Greco et al. (2019) review methodological advances and highlight persistent criticism related to weighting, aggregation and robustness in composite indices. Scholars such as Munda and Nardo (2009) argue for non-compensatory or nonlinear aggregation to prevent high scores in one dimension from offsetting weaknesses in another, while Hauser et al. (2018) and Michener (2015) caution that composite indicators can oversimplify complex realities if not complemented by qualitative evidence and structural analysis. This literature underscores that composite indices should be interpreted prudently and supplemented with sectoral assessments and contextual insights.

Together, these strands inform the empirical strategy of the present study. The provincial development measurement literature validates the use of PCA-based indices and clustering to summarise multidimensional data on Turkish provinces. Structural transformation scholarship explains why the composition of agriculture, industry and services provides critical information about development stage and highlights that services may complement rather than displace manufacturing. Research on composite indicators cautions against over-interpretation of synthetic measures and emphasises transparent construction and decomposition. Accordingly, this study treats the PCA-based composite index as the primary descriptive device for locating Çanakkale within Türkiye's provincial development distribution, while sectoral and peer comparisons are used only to interpret that index.

Data and Methodology

This section presents the data sources, details the construction of the six development indicators used in the composite index, explains how the variables were standardised and aggregated, reports diagnostic tests for the principal-component analysis (PCA) and outlines the analytic hierarchy adopted in the study. The approach follows best practice for composite indicator construction suggested by the OECD–JRC handbook (Nardo et al., 2005) and by Kaiser and Rice's (1974) guidelines for factorability.

Data Source, Scope and Indicator Selection

The study uses a cross-sectional dataset compiled from Turkish Statistical Institute Geographic Statistics Portal for 81 provinces in Türkiye in 2022, supplemented with investment data from the Ministry of Industry and Technology (2025) for 2001–2023. The raw dataset contains 21 candidate variables capturing sectoral outputs, population, employment, investment and entrepreneurship. Guided by the relevant literature on regional development and composite index construction, six variables were retained because they collectively reflect productive capacity, structural transformation, and future growth potential:

1. Per-capita sectoral production value (thousand TL). This is calculated by dividing the total combined production value of agriculture, industry and services by provincial population. It proxies overall productive capacity. Higher values indicate stronger provincial output per resident.
2. Start-ups per capita (number of start-ups per person). Entrepreneurial density indicates the dynamism of the local business environment. Previous studies associate start-up density with innovation and growth.
3. Investment with incentive certificate per capita (million TL). Certified investments capture capital deepening and future productive potential. The variable is normalised by population to make provinces comparable.
4. Agricultural production per capita (thousand TL). This measures dependence on primary-sector output. Because agriculture typically dominates at early stages of structural transformation, high values are expected to correlate negatively with development.
5. Industrial sector share (share of industrial output in total production). This indicator signals the degree of industrialisation; higher shares are associated with higher development levels in the literature on structural transformation.
6. Services sector share (share of services output in total production). A large services share may indicate a more advanced economy, although at intermediate stages services often remain underdeveloped. Provincial services output is divided by total production to derive this share.

These six indicators were chosen because they are theoretically linked to the stages of structural change and were available for all 81 provinces. Variables with high redundancy or missing values were excluded. The agricultural production indicator is retained even though it is expected to be negatively related to development, because its inclusion allows the index to capture the relative weight of the primary sector.

Table 1

The Variables and Their Anticipated Relationship with Provincial Development

Indicator	Unit	Conceptual rationale	Expected sign
Per-capita sectoral production value	Thousand TL per person	Overall productive capacity; higher output per resident implies more developed economy	Positive
Start-ups per capita	Start-ups per person	Entrepreneurial dynamism reflects innovation and adaptation	Positive
Investment with incentive certificate per capita	Million TL per person	Capital deepening and future productive potential	Positive
Agricultural production per capita	Thousand TL per person	Reliance on primary sector; large values indicate early stage of structural transformation	Negative
Industrial sector share	Share (0–1)	Degree of industrialisation; higher shares associated with higher development	Positive
Services sector share	Share (0–1)	Development of services; high services share indicates shift towards tertiary activities	Positive

Note. Prepared by the author in Python using Geographic Statistics Portal of Turkish Statistical Institute data.

Variable Construction and Descriptive Overview

All monetary variables were converted to per-capita terms by dividing them by provincial population. Sectoral shares were calculated as the ratio of each sector's output to the combined output of agriculture, industry, and services. The indicators were checked for plausibility, and the resulting sectoral shares are bounded between zero and one and sum to one for each province by construction.

To facilitate comparability across indicators, each variable was standardised using z-scores. Standardisation converts variables to a common scale with mean 0 and standard deviation 1, ensuring that indicators with large absolute values do not dominate the composite indicator (Moeller, 2025). The transformed variables are denoted $Z_1, \dots, Z_6$.

Table 2 reports descriptive statistics for the key variables used in the analysis and reveals substantial heterogeneity across Türkiye's provinces. Per-capita sectoral production ranges from 49 thousand TL to 268 thousand TL, indicating wide variation in output per resident. Start-up density ranges from 0.019 to 0.078 start-ups per person, reflecting meaningful differences in entrepreneurial activity. Investment per capita also varies considerably, from 0.030 million TL to 0.860 million TL, pointing to uneven patterns of certified investment across provinces. Agricultural production per capita ranges from 0.3 thousand TL to 49.9 thousand TL, indicating marked differences in agricultural output per resident. The sectoral shares are calculated using total agricultural, industrial, and services production as a common denominator. Accordingly, the three shares are bounded between zero and one and sum to one for each province. The industrial sector share has a mean of 0.512 and ranges from 0.089 to 0.846. The corresponding

mean shares are 0.224 for agriculture and 0.264 for services. These distributions indicate considerable cross-provincial variation in sectoral composition, particularly in the relative importance of industry and agriculture.

Table 2

Key Variables

Variable	Mean	SD	Min	25 %	Median	75 %	Max
Per-capita sectoral production value (k TL)	117.63	44.32	49.00	84.00	108.00	140.00	268.00
Start-ups per capita	0.047	0.012	0.019	0.040	0.047	0.053	0.078
Investment per capita (m TL)	0.148	0.124	0.030	0.070	0.120	0.190	0.860
Agricultural production per capita (k TL)	17.17	9.38	0.30	10.10	15.40	22.30	49.90
Industrial sector share	0.512	0.198	0.089	0.374	0.522	0.683	0.846
Agriculture sector share	0.224	0.155	0.001	0.104	0.204	0.306	0.726
Services sector share	0.264	0.115	0.106	0.189	0.238	0.303	0.727

Note. Prepared by the author in Python using Geographic Statistics Portal of Turkish Statistical Institute data.

Construction of the PCA-Based Composite Development Index

Principal-component analysis was used to construct a single composite indicator from the six standardised variables. PCA reduces the dimensionality of multivariate data by creating new uncorrelated variables (principal components) that successively maximise the variance (Jolliffe & Cadima, 2016). The first principal component captures the largest share of common variance and is therefore suited for synthesising the underlying development pattern.

Let $Z_{i1}, \dots, Z_{i6}$ denote the z-scores for province i . Denote by $\alpha = (\alpha_1, \dots, \alpha_6)$ the vector of loadings for the first principal component (PC1). The PCA-based composite development index for province i is defined as

$$\text{Index}_i = \alpha_1 Z_{i1} + \alpha_2 Z_{i2} + \alpha_3 Z_{i3} + \alpha_4 Z_{i4} + \alpha_5 Z_{i5} + \alpha_6 Z_{i6}. \quad (1)$$

The resulting scores are then rescaled to the interval [0,1] using a min–max transformation to facilitate interpretation. Higher values indicate higher levels of relative development.

PCA Suitability, Extraction and Robustness Checks

Before applying PCA, the data must satisfy factorability requirements. Kaiser–Meyer–Olkin (KMO) test. The KMO statistic measures sampling adequacy and ranges from 0 to 1; values above 0.60 indicate that correlations are sufficiently compact to justify factor analysis, whereas values below 0.50 are deemed unacceptable (Kaiser & Rice, 1974; Everitt & Howell, 2005). Bartlett’s test of sphericity examines the null hypothesis that the correlation matrix is an identity matrix; if the p-value is less than 0.05, the variables are sufficiently correlated for PCA (Bartlett, 1951).

Table 3*PCA Suitability Diagnostics*

Diagnostic	Statistic	Interpretation
Overall KMO	0.403	Below conventional adequacy threshold
Bartlett's test	$\chi^2 = 85.388$; $df = 15$; $p < 0.001$	Correlation matrix differs from identity

Note. Prepared by the author in Python using Geographic Statistics Portal of Turkish Statistical Institute data.

The KMO test for the six-variable specification yields an overall value of 0.403, indicating weak sampling adequacy and showing that the variables do not form a strong latent-factor structure in the strict factor-analytic sense. Variable-specific results suggest that agricultural production per capita contributes to this weakness; when this variable is excluded as a sensitivity check, the overall KMO rises to 0.584. This improvement confirms that the agricultural indicator reduces the compactness of the common variance structure. Nevertheless, the variable is retained in the baseline index because the purpose of the study is not to estimate a purely statistical latent factor, but to construct a theoretically grounded descriptive composite index that captures the broader interaction between productive capacity, entrepreneurship, investment, industrialisation, services, and primary-sector dependence. Therefore, the PCA-based index is interpreted cautiously as a descriptive measure of provincial development rather than as a strong latent-factor measurement model. Bartlett's test produces a chi-square of 85.39 ($df = 15$, $p < 0.001$), indicating that the correlation structure differs from the identity matrix and that PCA is still warranted. Table 4 reports the KMO values for each variable.

Table 4*Variable-Specific KMO Statistics*

Indicator	KMO
Per-capita sectoral production value	0.662
Start-ups per capita	0.345
Investment per capita	0.662
Agricultural production per capita	0.253
Industrial sector share	0.469
Services sector share	0.254

Note. Prepared by the author in Python using Geographic Statistics Portal of Turkish Statistical Institute data.

The variable-specific KMO values were 0.662 for per-capita sectoral production, 0.345 for start-ups per capita, 0.662 for investment per capita, 0.253 for agricultural production per capita, 0.469 for industrial share, and 0.254 for services share. These values suggest that per-capita production and investment contribute most to common variance, while agricultural and services indicators have relatively low sampling adequacy. Even though the overall KMO is low, the significant Bartlett test and the exploratory nature of this study justify proceeding with

PCA. The low KMO implies that the composite index should be interpreted as a descriptive summary rather than a strong latent-factor measurement model.

Extraction and Retention of Components

The eigenvalues associated with each principal component are shown in Table 5. The first component has an eigenvalue of 1.95, explaining 32.1 % of the total variance. The second and third components explain 20.7 % and 19.5 %, respectively. Although the Kaiser criterion (eigenvalues > 1) would suggest retaining the first three components, only the first component is retained to construct a single development index, in line with the analytical objective of summarising provincial development.

Table 5

Eigenvalues and Explained Variance

Component	Eigenvalue	Explained variance (%)	Cumulative variance (%)
PC1	1.951	32.117	32.1
PC2	1.259	20.729	52.8
PC3	1.186	19.522	72.3
PC4	0.921	15.161	87.5
PC5	0.482	7.941	95.4
PC6	0.275	4.530	100.0

Note. Prepared by the author in Python using Geographic Statistics Portal of Turkish Statistical Institute data.

Interpretation of Loadings and Robustness Check

Table 6 presents the loadings of the first principal component. Positive loadings imply that higher indicator values increase the composite index, while negative loadings reduce it. The negative loading of agricultural production per capita indicates that, within the structure of the index, stronger dependence on agricultural production is associated with lower composite development scores because it reflects a weaker transition toward industrialisation and higher value-added economic activities. In this application, the first component loads positively on per-capita production (0.245), start-ups per capita (0.421), investment per capita (0.569), industrial sector share (0.598) and services sector share (0.178). Agricultural production per capita has a negative loading (−0.225), implying that provinces with a large primary sector receive lower development scores—consistent with the expected sign specified in Table 1. This does not imply that agriculture is undesirable; it merely reflects the structural pattern that agricultural dominance is characteristic of less developed provinces.

Table 6*PC1 Loading Matrix*

Indicator	PC1 loading
Per-capita sectoral production value	0.245
Start-ups per capita	0.421
Investment per capita	0.569
Agricultural production per capita	-0.225
Industrial sector share	0.598
Services sector share	0.178

Note. Prepared by the author in Python using Geographic Statistics Portal of Turkish Statistical Institute data.

To assess the robustness of the PCA-based index to the weighting scheme, an equal-weight index was computed by averaging the standardised indicators, reversing the sign of agricultural production to align with the PCA loading. The correlation between the PCA-based index and the equal-weight index is 0.95, indicating that provincial rankings are largely insensitive to the choice of weights. Nevertheless, the PCA approach is preferred because it accounts for the actual covariance structure of the data.

Analytical Use of the Index in the Empirical Assessment

The composite development index serves as the primary analytical tool in the empirical assessment. Provinces are ranked according to their index scores, and descriptive comparisons across high, medium and low development clusters are subsequently undertaken. Sectoral shares and per-capita values are used to interpret the index scores rather than to construct an alternative measure. A k-means clustering of the index scores is implemented as a supplementary classification device, yielding high, medium and low development typologies that aid interpretation but do not alter the ranking. Throughout the analysis, caution is exercised due to the low KMO statistic; the index is interpreted as a pragmatic descriptive summary of correlated provincial indicators rather than a latent-factor measurement model.

Empirical Results: Provincial Development Patterns and Çanakkale's Relative Position

This section interprets the composite development index derived in the previous section. It first examines the overall distribution of provincial development scores in Türkiye and then classifies provinces into high-, medium- and low-development typologies using a k-means clustering. The final subsections benchmark Çanakkale against both the national distribution and a population-based peer group and synthesize what these comparisons reveal about Çanakkale's structural position.

National Distribution of the Composite Development Index

The composite development index ranges from 0 (least developed) to 1 (most developed), with a national mean of 0.35 and median of 0.34. The index is moderately right-skewed—its skewness is about 0.57, indicating that a small number of provinces achieve very high scores while the majority cluster around the middle. The lower quartile, median and upper

quartile of the distribution are approximately 0.23, 0.34 and 0.48, respectively. A few provinces approach the theoretical maximum of 1, while the lowest province scores 0.

Provincial rankings based on the index reveal substantial disparities. Table 7 lists the five highest- and five lowest-scoring provinces. Zonguldak, Yalova, Kocaeli, Kırklareli and Tekirdağ occupy the top positions, with index values between 0.66 and 1.00. At the bottom of the distribution are Bitlis, Muş, Kars, Hakkâri and Bayburt, all scoring below 0.05. Çanakkale's development index is 0.416, placing it 28th among 81 provinces and slightly above the national mean.

Table 7

Selected Provincial Rankings Based on the Composite Development Index

Province (Top)	Development index	Rank	Province (Bottom)	Development index	Rank
Zonguldak	1.000	1	Bitlis	0.047	77
Yalova	0.913	2	Muş	0.045	78
Kocaeli	0.750	3	Kars	0.032	79
Kırklareli	0.687	4	Hakkâri	0.002	80
Tekirdağ	0.660	5	Bayburt	0.000	81

Note. Prepared by the author in Python using Geographic Statistics Portal of Turkish Statistical Institute data.

Development Typologies as a Supplementary Classification

To make the continuous index easier to interpret, provinces were classified into high, medium, and low development typologies using k-means clustering based on the six standardised indicators. Cluster analysis groups observations by minimising differences within clusters while maximising differences between clusters. In this framework, the k-means algorithm iteratively assigns each province to the nearest cluster centroid and then recalculates the centroids until a stable solution is reached (Templ et al., 2008; Jolliffe & Cadima, 2016). In the study, clustering functions as a complementary interpretative device and does not affect the underlying index values or provincial ranking.

The algorithm identified three clusters: 27 provinces in the high-development group, 28 provinces in the medium group and 26 provinces in the low group. The clusters are ordered by the mean development index and labelled accordingly. Their index ranges, mean scores and some representative provinces are summarised in Table 8. High-development provinces have index values between 0.38 and 1.00 (mean $\approx$ 0.55). They include industrial powerhouses such as Zonguldak, Yalova and Kocaeli. Medium-development provinces have scores between 0.07 and 0.53 (mean $\approx$ 0.33) and include provinces such as Antalya, Adana and Afyonkarahisar. Low-development provinces score below 0.34 (mean $\approx$ 0.15) and encompass provinces like Bayburt, Hakkâri and Kars.

Table 8*Development Typologies from K-Means Clustering (Ordered by Mean Index)*

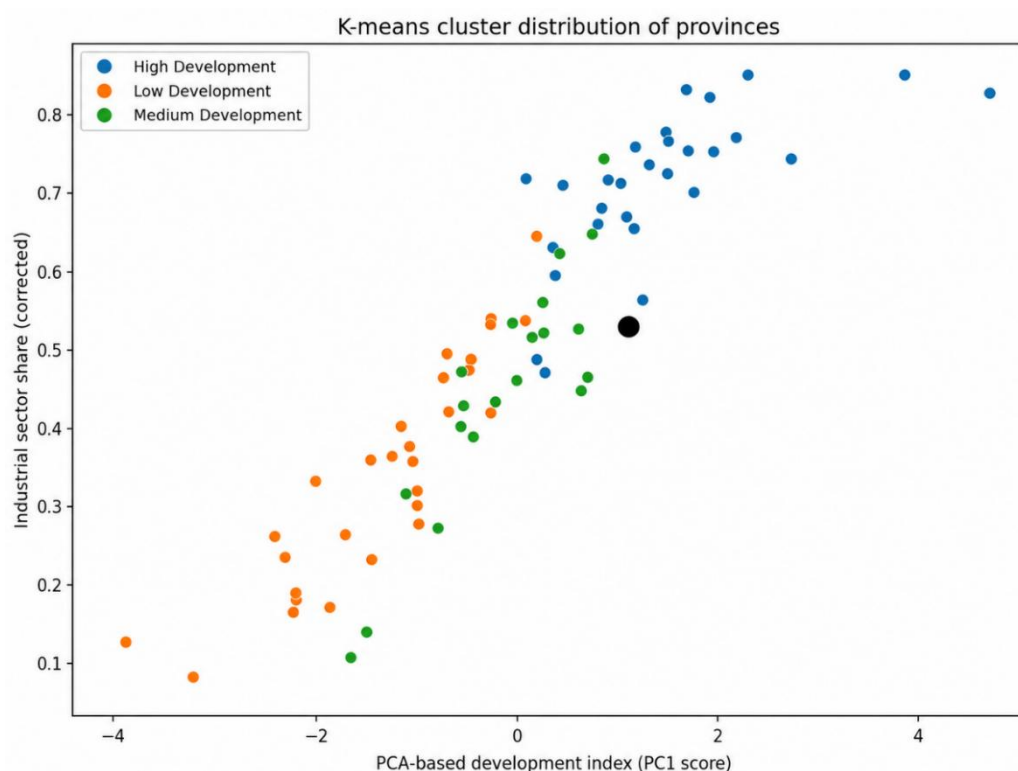
Development typology	Number of provinces	Index range	Mean index	Example provinces
High development	27	0.38–1.00	0.553	Zonguldak, Yalova, Kocaeli
Medium development	28	0.07–0.53	0.331	Antalya, Adana, Afyonkarahisar
Low development	26	0.00–0.33	0.154	Bayburt, Hakkâri, Kars

Note. Prepared by the author in Python using Geographic Statistics Portal of Turkish Statistical Institute data.

To visualise the three-group typology, Figure 1 plots provinces' first principal-component (PC1) scores against their industrial sector shares, with colours denoting the k-means clusters derived from the six standardised indicators.

Figure 1

K-Means Cluster Distribution of Provinces by Composite Development Index and Industrial Sector Share



Note. Provinces are classified using k-means clustering based on six standardised development indicators: per-capita production, start-ups per capita, investment per capita, agricultural production per capita, industrial-sector share, and services-sector share. The horizontal axis plots the PCA-based composite development score (PC1), while the vertical axis plots the industrial-sector share. Colours denote cluster membership, and the larger black marker identifies Çanakkale. Prepared by the author using Python where, Arial font customisation is not supported.

The figure shows that high-development provinces are generally concentrated at higher levels of both the development index and industrial sector share, while low-development provinces are positioned toward the lower end of the distribution. Çanakkale, shown as the larger black point, appears within the medium-development group. This confirms its transitional position: the province performs above the lower-development cluster but remains distinct from the more industrialised high-development provinces.

Sectoral Structure by Development Typology

The typologies differ markedly in their sectoral composition and per-capita economic values. Table 9 reports the mean values of the six indicators for each cluster. High-development provinces have the strongest per-capita production (approximately 139.1 k TL), substantial investment per capita (approximately 0.228 M TL), and the highest industrial share (approximately 71.3%). Their start-up density averages 0.0481 per person, while agriculture and services account for approximately 9.5% and 19.3% of total production, respectively. This profile reflects a strongly industrialised development pattern.

Medium-development provinces record per-capita production of approximately 118.0 k TL and investment per capita of approximately 0.120 M TL, but they have the highest start-up density (approximately 0.0541). Their sectoral structure is more mixed: industry accounts for approximately 46.5% of output, agriculture for 30.4%, and services for 23.1%. Agricultural production per capita is also highest in this group (approximately 28.74 k TL), indicating a transitional profile in which entrepreneurial dynamism coexists with a substantial primary-sector base.

Low-development provinces exhibit the weakest per-capita production (approximately 98.0 k TL), lowest start-up density (approximately 0.0404), and lowest investment per capita (approximately 0.096 M TL). Their industrial, agricultural, and services shares average approximately 36.5%, 28.3%, and 35.2%, respectively. Rather than being dominated by a single sector, this group combines relatively weak productive capacity and capital deepening with a less industrially concentrated economic structure.

Table 9

Mean Indicator Values by Development Typology

Development typology	Per-capita production (k TL)	Start-ups per capita	Investment per capita (M TL)	Agricultural production per capita (k TL)	Industrial share	Services share	Mean index
High	139.1	0.0481	0.228	11.69	0.713	0.193	0.553
Medium	118.0	0.0541	0.120	28.74	0.465	0.231	0.331
Low	98.0	0.0404	0.096	13.90	0.365	0.352	0.154

Note. Prepared by the author in Python using Geographic Statistics Portal of Turkish Statistical Institute data, sectoral shares were calculated as fractions of total provincial production; by construction, the agriculture, industry, and services shares sum to one for each province.

The patterns in Table 9 underscore the strong association between industrialisation and development noted in the literature. High-development provinces have nearly quadruple the industrial share of low-development provinces. The services share, however, does not increase monotonically with development; it remains around 22 % across all clusters, suggesting that

the services sector does not differentiate provincial development as strongly as industry or investment. Agricultural production per capita declines in the high-development cluster but rises again in the medium cluster, reflecting regions where agriculture remains important yet is complemented by growing industrial and entrepreneurial activity.

Çanakkale's Relative Development Position

Çanakkale's composite development index of 0.416 places it in the medium-development typology. Its score exceeds the national mean of 0.35 and lies between the national median and upper quartile of the distribution. Although Çanakkale performs above the average provincial level, its index remains below the mean score of the high-development cluster (0.553). Ranked 28th among 81 provinces, it falls within the upper third of the national distribution. Its indicator profile helps explain this intermediate position:

- Per-capita production: Çanakkale produces 90 k TL per person, well below the national mean of 117.6 k TL. This gap reflects lower overall output despite a reasonably diversified economy.
- Start-ups per capita: The province boasts 0.064 start-ups per person, higher than the national average (0.0468) and signalling strong entrepreneurial activity.
- Investment per capita: At 0.300 M TL, Çanakkale's investment per capita more than doubles the national mean (0.148 M TL), indicating robust capital deepening and future productive potential.
- Agricultural production per capita: Çanakkale's 40.6 k TL far exceeds the national average (17.17 k TL). Because this indicator carries a negative loading in the PCA, the large agricultural sector pulls the development index downward.
- Industrial and services shares: Çanakkale's industrial share (0.480) is modestly below the national average (0.512), while its services share (0.170) is substantially below the national mean (0.264). This indicates that the province's sectoral composition is less industrial- and services-intensive than the average provincial structure.

These figures are summarised in Table 10. They reveal a mixed structural profile: Çanakkale combines high investment and entrepreneurial density with moderate industrialisation and a very large agricultural base. The mixture of modernising and traditional elements explains why the province does not reach the high-development cluster despite its strong capital inflow.

Table 10*Çanakkale's Indicator Values Compared with National Averages*

Indicator	Çanakkale	Türkiye average	Interpretation
Per-capita production (k TL)	90.0	117.6	Below national mean
Start-ups per capita	0.064	0.0468	Above national mean
Investment per capita (M TL)	0.300	0.148	More than double national mean
Agricultural production per capita (k TL)	40.6	17.17	More than double national mean; negative loading
Industrial share	0.48	0.512	Near national mean
Services share	0.17	0.264	Below national mean
Development index	0.416	0.348	Above national average

Note. Prepared by the author in Python using Geographic Statistics Portal of Turkish Statistical Institute data.

Çanakkale in Peer Perspective

Given the substantial variation in provincial population size, the empirical analysis also compares Çanakkale with a population-based peer group. Peer provinces are identified as those whose 2022 population lies within $\pm 20\%$ of Çanakkale's population. On this basis, six provinces are included: Antalya, Balıkesir, Batman, Çankırı, Kastamonu, and Kırıkkale. This comparison is intended as a descriptive benchmark rather than a full control for underlying structural differences.

Table 11 compares Çanakkale's indicators with the peer mean and the national mean. Peers have higher per-capita production (126.8 k TL) than both Çanakkale and the national average, reflecting more efficient production. They also have lower start-up density (0.049) and investment per capita (0.133 M TL) than Çanakkale, suggesting that Çanakkale is unusually entrepreneurial and capital intensive for its population size. Peers' agricultural production per capita (16.62 k TL) is far lower than Çanakkale's, and their industrial share (0.593) is higher. This comparison underscores that Çanakkale's medium-development status stems from its high investment and entrepreneurial activity being offset by a large agricultural base and moderate industrialisation.

Table 11*Çanakkale, Peer Mean, and National Mean*

Indicator	Çanakkale	Peer mean	National mean
Per-capita production (k TL)	90.0	126.8	117.6
Start-ups per capita	0.064	0.049	0.0468
Investment per capita (M TL)	0.300	0.133	0.148
Agricultural production per capita (k TL)	40.6	16.62	17.17
Industrial share	0.48	0.593	0.512
Services share	0.17	0.217	0.264
Development index	0.416	0.393	0.348

Note. Prepared by the author in Python using Geographic Statistics Portal of Turkish Statistical Institute data.

Interpreting Çanakkale's Development Pattern

The empirical results suggest that Çanakkale occupies a nuanced position within the provincial development structure. It cannot be classified either as a low-development, agriculture-dominated province or as a high-development industrial hub. Rather, it stands in a transitional middle position. Its strong investment performance and relatively dynamic start-up activity indicate a modernising economy with significant growth potential; however, its substantial agricultural base and only average industrial share constrain its composite development performance. In this sense, Çanakkale reflects a mixed structural pattern, combining features associated with both lower- and higher-development provincial profiles.

Looking forward, Çanakkale's upward movement in the national development ranking will depend on whether its substantial investment and entrepreneurial activity translate into higher industrial output and more diversified services. If investment continues to flow into productive sectors and start-ups scale up, Çanakkale could shift into the high-development group. Conversely, if the agricultural sector remains dominant and services lag, the province may experience persistent medium-level development. Policymakers should therefore focus on strengthening linkages between investment, entrepreneurship and industrial output while facilitating the transition of labour and resources from agriculture to higher value-added activities.

Conclusion and Policy Implications

This study assesses provincial development differences in Türkiye and positions Çanakkale within that wider distribution through a more coherent and methodologically disciplined framework. In this study, the PCA-based composite development index serves as the primary analytical measure. Descriptive comparisons, k-means clustering, and peer benchmarking are used to contextualise and interpret provincial differences without altering the underlying index-based assessment. Rather than deploying multiple parallel techniques without a clear analytical centre, the study advances a focused argument: a compact composite index, constructed from indicators of productive capacity, entrepreneurship, investment, and sectoral

structure, provides a transparent basis for assessing provincial development and locating Çanakkale within the national distribution.

The results reveal substantial heterogeneity across Türkiye's 81 provinces. The national distribution of the development index is uneven, with only a small number of provinces in the upper tail and a broad concentration in the middle range. High-development provinces are characterised by strong per-capita production, greater investment intensity, and higher industrial shares. Low-development provinces show weaker productive capacity, lower entrepreneurial density, lower investment per capita, and more fragile structural profiles. Medium-development provinces occupy an intermediate position, but they are not simply average cases. They often combine elements of dynamism with structural incompleteness, suggesting that development is better understood as a transitional process than as a fixed label.

Within this national pattern, Çanakkale emerges as a medium-development province with a distinct mixed structure. Its development index places it above the national mean but below the threshold of the high-development group. This is important because it shows that Çanakkale is neither a lagging, agriculture-dominated province nor a mature industrial-service pole. Instead, it appears as a transitional province in which strengths and weaknesses coexist in a balanced but incomplete configuration. On the positive side, Çanakkale displays strong entrepreneurial activity and very high investment per capita, both of which point to development potential, adaptability, and future productive capacity. At the same time, these advantages are offset by lower per-capita production than the national average, only moderate industrialisation, and a relatively large agricultural base. Within the structure of the composite index, this combination constrains the province's upward movement.

The typology analysis reinforces this interpretation. High-development provinces are defined by much stronger industrial profiles, whereas low-development provinces tend to combine weaker productive performance with limited investment and entrepreneurship. Çanakkale's position in the medium cluster reflects a more mixed economic composition. The province has clearly moved beyond a purely primary-sector structure, but it has not yet developed the industrial depth and higher-value service base needed to join the upper tier. Peer comparison confirms this pattern. Relative to similarly populated provinces, Çanakkale performs well in entrepreneurship and investment, but remains weaker in per-capita production and industrial share. In other words, the province has momentum, but that momentum has not yet been fully translated into a stronger production structure.

These findings support a broader policy lesson: regional development policy should not rely on single indicators such as income, total production, or population size. Provinces may appear similar on one dimension while differing sharply on others. The case of Çanakkale demonstrates why multi-dimensional assessment is necessary. A province can attract investment and generate entrepreneurial activity, yet still remain structurally constrained by insufficient industrial upgrading and an underdeveloped service base. For this reason, place-based policy should be designed around the structural profile of each province rather than uniform national formulas.

For Çanakkale, the main policy priority is to strengthen the link between existing investment flows and higher value-added production. Investment alone is insufficient if it does not generate durable gains in industrial productivity, technological capability, and sectoral upgrading. Provincial and regional policy should therefore direct investment toward activities that deepen industrial capacity, improve processing and transformation within existing sectors, and create stronger forward and backward linkages. This is especially relevant in a province

where agriculture remains important. The goal should not be to reduce agriculture, but to raise its productivity and integration with industry through agro-processing, logistics, branding, and export-oriented value chains.

A second implication concerns entrepreneurship. Çanakkale's strong start-up performance is one of its clearest advantages, but start-up density contributes to long-term development only if new firms survive, scale, and connect to broader production networks. Policy should therefore move beyond simple business creation incentives and place greater emphasis on firm growth, innovation support, managerial capability, digitalisation, and market access. Entrepreneurship should be treated not as an isolated sign of local vitality, but as a mechanism for accelerating structural transformation.

A third implication relates to services. The results suggest that services do not currently differentiate higher development as strongly as industry, yet a weak service base can still limit development quality. For Çanakkale, the challenge is not the expansion of low-productivity services, but the strengthening of services that complement production, investment, tourism, logistics, and knowledge diffusion.

At the same time, the results warrant methodological caution. The low KMO statistic indicates that the composite index should be interpreted as a theory-informed descriptive measure rather than as evidence of a single, strongly defined latent dimension of provincial development. Accordingly, the index is most useful for disciplined comparison of provinces' relative economic structures and development profiles, not as a definitive measure of their absolute level of development. This interpretation is consistent with the study's analytical purpose: to integrate productive capacity, entrepreneurship, investment, and sectoral composition into a transparent framework for evaluating Çanakkale's relative position within Türkiye.

Overall, the evidence indicates that Çanakkale is a transitional provincial economy with meaningful strengths but incomplete structural upgrading. Its current position is promising rather than fully mature. If investment, entrepreneurship, and sectoral policy are aligned more effectively with industrial upgrading and value-added diversification, the province has the capacity to move upward within the national development distribution. In that sense, the case of Çanakkale illustrates a broader lesson for Türkiye: regional development policy is most effective when it identifies not only where provinces stand, but also what kind of structural transformation is required for them to advance.

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