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Is there a Proven Relationship Between the Economic Complexity of Moroccan Regions and their Well-being?

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Abstract
Intangible capacities such as creativity, innovation and know-how are increasingly becoming essential conditions for territorial development. These capacities refer to the paradigm of economic complexity which synthesizes the competitive capacity of territories. Also, we calculated the regional economic complexity of Morocco as well as indices related to the diversification of regions and the ubiquity of activities. We then highlight the link between the complexity of regions and their well-being. For this, we used a microdata base of nearly 8000 industrial establishments over the period from 1990 to 2015 for the twelve Moroccan regions and 223 activities. Thus, it turns out that Moroccan regions form a space-product network around nuclei of different densities illustrating productive systems of such different maturities. This reveals the emergence of ecosystems around complementary activities leading to an increase in the complexity of the regions associated with them. In addition, regions of high complexity exhibit high diversity combined with low ubiquity with relatively stable regional dynamics between 1990 and 2015. The complexity spreads from the economic capital Casablanca-Settat to the neighboring regions with a high intermediate complexity then those adjacent with a low intermediate complexity before spreading to the other southern regions with low complexity. Finally, it turns out that a high level of economic complexity is linked to a high level of certain components of objective well-being. Thus, high economic complexity is linked to such high economic development accompanied by qualified human capital and advanced innovation improving their living conditions and health with, however, low levels in terms of the environment and governance.

Keywords Complexity · Ubiquity · Diversity · Revealed comparative advantage · Well-being

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Introduction

The competitiveness of countries is taking more and more space in contemporary economic debate as potential gains inherent in international openness. However, these gains are complex and difficult to grasp if the analysis remains confined to traditional fields of economic analysis (Bellone & Chiappini, 2016). This concept of competitiveness was initiated by the United States in the 1980s[1] given the opening up of the world economy and the deregulation of markets giving rise to a feeling of loss of market share to the benefit of Southeast Asia. The concept was taken up by several institutions in the 1990s, developing it and enriching it with specific variations. Hatzichronoglou (1996) highlighted the role of regions in consolidating the country's competitiveness by improving the capacity of companies located there to generate high incomes and jobs despite the opening of the market to competition.

The 2000s were the period when innovation and new technologies played their part in the debate as vectors for the competitiveness of nations and the consolidation of their growth. Finally, the 2010s, following the 2008 recession, removed any ambiguity as to the impact of globalization on the competitiveness of countries but also on their regions in terms of both the spatial effects of growth and those of loss of productivity closely linked to their competitiveness.

The measurement of the competitiveness of countries and regions has taken paths as diverse as the debates that prefigured it. The competitiveness indicators that come up most often are those related to trade performance based on foreign trade data such as the different variants[2] of the indices of revealed comparative advantages proposed by Balassa (1965).

The latest generation of these indices, linking competitiveness to the ability of nations to innovate and push back their technological frontiers, concerns the Economic Complexity Indicators (ECI) proposed by Hidalgo and Hausmann (2009) on the basis of approaches related to statistical physics[3] and econophysics.[4] The calculation of the economic complexity index is based on the diversification of a country and the ubiquity of its products, using foreign trade data as a means of assessing the country's competitive capacity in the future to export.

Thus, the complexity of a country is revealed through its positioning in the product space linking countries to exported products. Indeed, countries that have developed broader ties within this space are more willing to diversify and develop. Thus, these barriers to entry into the product space may explain, in part, the lack of convergence of the global economy but also the resilience to external shocks of economies that are not well positioned in this space.

[1] A multidisciplinary commission has been set up by President Ronald Reagan to make proposals likely to increase the industrial competitiveness of American exporters (US Government Printing Office, 1985).

[2] French (2017) assessed the relevance of several measures in specifying fundamental patterns of countries' comparative advantage and identifying their competitors in a given market.

[3] Discipline whose objective is the study of macroscopic systems through the behavior of their microscopic components.

[4] Approach attempting to study complex economic or financial phenomena through theories developed in the field of physics. For a synthetic review of the discipline see (Chakraborti et al., 2011).

The extension of this principle to the regions is likely to provide information on the capacity of the latter to resist the opening up of the national economy and to derive the best benefit from the globalization of the markets while ensuring a fair distribution of the fruits of growth, in particular, and well-being in general. However, Boumahdi and Zaoujal (2023) have highlighted the role of the accumulation of both tangible and intangible capital in improving regional well-being. Indeed, intangible capacities, such as creativity, innovation and know-how, are increasingly becoming essential conditions for the progress of nations. These intangible capacities of territories, however diversified they may be, refer to the paradigm of economic complexity.

Studies established on this subject at the territorial level remain relatively less developed than those made at the country level (Mesagan & Vo, 2023; Nguea, 2024; Nguea & Noumba, 2024) given the limits both conceptually and in terms of information. In this article, we will endeavor to assess the regional economic complexity of Morocco through the exports of their industrial establishments from 1990 to 2015[5]. Indeed, the industry generates 50% of Morocco's total exports in 2015[6] and has an important role in the accumulation of knowledge and the strengthening of the competitiveness of regional players in the face of international competition. We will also calculate indices related to the diversification of regions and the ubiquity of activities. Subsequently, we will try to highlight the link between the complexity of regions and their well-being.

Method

Economic Complexity

The approach for measuring the ECI of regions is the same as that developed for countries by Hidalgo and Hausmann (2009).[7] It begins with the construction of a network linking the regions to the activities by links which will be all the more important as the exports belonging to the type of corresponding activity and in the corresponding region are. The next step consists of transforming this bipartite network into an adjacency matrix $M_{R,i}$ which will be the key tool for the construction of the index with $M_{R,i} = 1$ if the region R has a revealed comparative advantage (RCA) in activity i (i.e., $RCA_{R,i} > 1$) and 0 otherwise.

The RCA is defined as the ratio between the exports of a given region in a given activity and the theoretical rate of importance of this activity in this region:

$$RCA_{R,i} = \frac{\frac{X_{Ri}}{\sum_i X_{Ri}}}{\frac{\sum_R X_{Ri}}{\sum_R \sum_i X_{Ri}}} \quad (1)$$

[5] Most recent date for data available with fine granularity to adopt the 12-region breakdown and to calculate complexity indices.

[6] This share increased to 59% in 2021.

[7] In this sense, we will speak later of an "R" region in the calculation of the ECI, but this can be replaced indifferently by any type of territory from the most macro to the most micro.

where X_{Ri} represents the total exports of a region "R" in a specific activity "i".

The diversity of an "R" region is evaluated by the number of activities in which it has a comparative advantage, based on the adjacency matrix $M_{R,i}$:

$$Diversity_R = k_{R,0} = \sum_i M_{Ri} \tag{2}$$

Ubiquity is assessed by the number of regions with a comparative advantage in a given activity "i":

$$Ubiquity_i = k_{0,i} = \sum_R M_{Ri} \tag{3}$$

Subsequently, the average ubiquity of a region, relative to the activities in which it has a comparative advantage, is calculated as follows:

$$k_{R,1} = \left. \Sigma_i \left(k_{0,i} M_{R,i}\right) \right/ \Sigma_i M_{R,i} \tag{4}$$

These measures are generated more accurately by correcting the diversity of regions by the average ubiquity of activities and the ubiquity of different activities by the average diversity of regions that export to them. This recursion is expressed as follows:

$$k_{R,N} = \frac{1}{k_{R,0}} \sum_i M_{Ri} k_{i,N-1} \tag{5}$$

$$k_{i,N} = \frac{1}{k_{0,pi}} \sum_R M_{Ri} k_{R,N-1} \tag{6}$$

and by introducing Eqs. (5). into (4)., the term $k_{R,N}$ can finally be rewritten as follows:

$$k_{R,N} = \sum_{R'} \widetilde{M_{RR'}} k_{R',N-2} \tag{7}$$

where the matrix $\widetilde{M_{RR'}}$ accounts for regions exporting on similar activities, weighted by the inverse of the ubiquity of this activity $k_{i,0}$ and normalized by the diversity $k_{R,0}$.

$$\widetilde{M_{RR'}} = \sum_i \frac{M_{Ri} M_{R'i}}{k_{R,0} k_{0,i}} \tag{8}$$

Given $\vec{K}$, the eigenvector associated with the 2nd largest eigenvalue of $\widetilde{M_{RR'}}$, and <.> and std (.), respectively, the mean value and standard deviation functions, the economic complexity index (ECI) of region R is defined as follows:

$$\overrightarrow{ECI} = \frac{\vec{K} - \left\langle \vec{K} \right\rangle}{std\left(\vec{K}\right)} \tag{9}$$

Despite the criticisms[8] relating to the approach proposed for the evaluation of the economic complexity of countries, the fact remains that the non-monetary indices which result from it are correlated with GDP per capita and could be candidates as predictor variables of growth. Hidalgo and Hausmann (2009) tested the predictive quality of the ECI by regressing the growth rate of GDP per capita on different measures of economic complexity and on the initial level of GDP per capita in PPP of a sample of countries on a period of 20 years with several variants to test the robustness.

Felipe et al. (2012) endorsed this link, adopting the same approach as Hidalgo and Hausmann (2009) with respect to 124 countries and 5107 products, with the additional fact that the sensitivity of this link between the shares of export of the most complex products and income increases as one moves away from the average level of complexity. Hausmann et al. (2007) explain this growth by the transfer of resources from low productivity activities to those with higher productivity which are subject to an elastic demand so that a country can export them in large quantities in keeping the terms of trade at levels favorable to its competitiveness.

At the subnational level, Gao & Zhou (2018a) concluded that there is a strong correlation between the ECI and the logarithm of GDP per capita for the Chinese provinces, ($\rho = 0.667$ and p-value $= 4.1.10^{-5}$). Balsalobre et al. (2019) noted also the opportunity of the ECI as a good predictor of GDP per capita for the 50 Spanish provinces, in particular, in the long term (10-year horizon).

Recently, Ivanova (2022) showed that the accuracy of growth forecasts for Chinese provinces can be significantly improved by integrating the economic complexity index as a predictor variable in addition to the usual variables such as employment, income and investment.

At the transcontinental level, Buccellato & Corò (2020) have also shown that the magnitude of convergence is greater in a β-convergence model conditional on economic complexity[9]. However, they qualified this observation by showing that economic complexity certainly enabled the regions of Eastern Europe to catch up with their growth delay at the beginning of the 2000s[10], but that it enabled the German regions to widen their gaps with other European regions in the post-2008 economic crisis period.

Well-being

In order to highlight a possible relationship between the economic complexity of the regions of Morocco and their well-being, we used synthetic indicators of objective well-being and its components calculated by Boumahdi and Zaoujal (2023) by

[8] In his review of the strengths and limitations of the approach, Hickson (2017) highlights the shortcomings of the latter, including, in particular, the fact that it does not take into account services or asymmetric development shocks (technological leaps, natural disasters, conflicts, …) and that the exported goods are assumed to be entirely produced by the last exporting country.

[9] Based on a spatial econometric model in 191 EU28 regions over the period 2010–2016. The specification adopted includes the spatial lag of the error term, to capture a potential connectivity between regional productive systems, in addition to the spatial lag of the dependent variable in order to control for the effects of geographic proximity.

[10] Explained by an evolution of the productive system of these regions towards more complex manufacturing activities by benefiting from FDI, in particular, those from Germany.

aggregation of 15 indicators (Table 1). We chose the objective measurement rather the subjective concept because we can not do a benchmark with a "uniform" survey covering the self-satisfaction wellbeing evaluation which is the most used method for measuring subjective wellbeing (Bravi et al., 2023; Magazzino et al., 2024).

After a standardization of those indicators in a normalized scale [0,100] by the minmax method, (Boumahdi & Zaoujal, 2023) aggregated them by theme, then by domains to create an overall Synthetic Index of Well-being and several synthetic indexes of its components (domains and themes) (Fig. 1). According to Boumahdi and Zaoujal (2023), the scores were normalized because the indicators have different units and scales. Indeed, the index developed by the two authors is a composite index of well-being using aggregative-compensative approach as suggested by the guide proposed by Mazziotta and Pareto (2013) which begins by distinguishing whether the individual indicators are substitutable or not .

Results and Discussion

Assessment of Morocco's Regional Economic Complexity

To calculate the regional economic complexity in Morocco, we used a microdata base of nearly 8000 industrial establishments[11] over the period from 1990 to 2015. This microdata base provides information on the exports of these establishments according to a breakdown of 223 activities industrial. We have established a passage key to have the distribution of data according to the division into twelve regions that has come into effect since 2015. We chose the current 12 regions division since it is the basis for all public policies implemented at national and regional level. Thus, our article could have useful implications in terms of analysis and factual propositions.

Three regions concentrate 80% of manufactured exports over the period 1990–2015 (Casablanca-Settat (53%), Marrakech-Safi (14%) and Tanger Tétouan Alhoceima (13%)). By sectors, the structure of manufactured exports is slightly different, especially in the agri-food industries with Souss Massa as the main export region (27%) and in the electric and electronic industries with Tanger Tétouan Alhoceima as the second main export region (40%) after Casablanca-Settat (51%) Table 2.

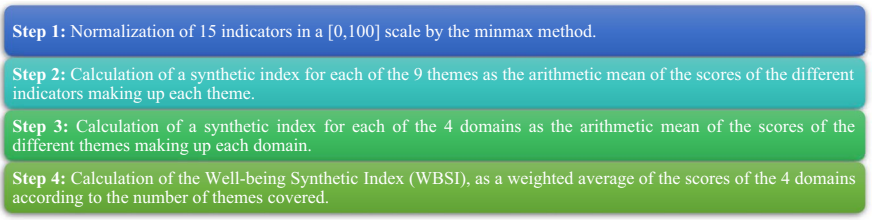
Subnational studies have often been based on alternative data to exports by country according to the finest harmonized system (HS) customs nomenclature, as recommended in the founding supranational study Hidalgo & Hausmann (2009). Thus, Gao & Zhou (2018a) used financial data on companies listed on the Shanghai and Shenzhen stock exchanges to assess the economic complexity of Chinese provinces. These data cover 2690 companies broken down by 31 provinces and 70 sectors between 1990 and 2015. Balsalobre et al. (2019) have used international and subnational trade data by mode of transport (road, rail, air and maritime) between the 50 Spanish provinces over the period 1995–2015. International trade covers more than

[11] 2014 and 2015 recorded a lower coverage rate than the average over the period.

Table 1 Indicators selected by domain and by theme to evaluate well-being and its compenents

Synthetic index		Domain	Theme	Indicator
Well-being Synthetic Index (WBSI),	Economic Synthetic Index (ESI)	Economy	Development	GDP per capita
				Share of the VA of manufacturing industry
			Human capital	Share of working people with at least an upper secondary diploma
				Share of employment in manufacturing industry
			Labour market	Employment rate
				Unemployment rate
			Innovation	Patent applications
	Social Synthetic Index (SSI)	Social	Living conditions	Number of rooms per person
				Share of households with broadband internet access
			Health	Rate of active physicians
				Infant mortality rate
			Gender	Gender gap in activity rate, 15-64 years old (female – male)
				Gender gap in the unemployment rate, 15-64 years old (female – male)
		Environment	Environment	Air pollution, average level of PM 2.5
		Governance	Governance	Participation rate in general elections

Source: (Boumahdi & Zaoujal, 2023) adapted by the authors



Source: (Boumahdi & Zaoujal, 2023) adapted by authors

Fig. 1 Aggregation methodology of the Synthetic Index of Regional Well-Being and its components

Table 2 Structure of manufactured exports by region and major sector over the period 1990–2015

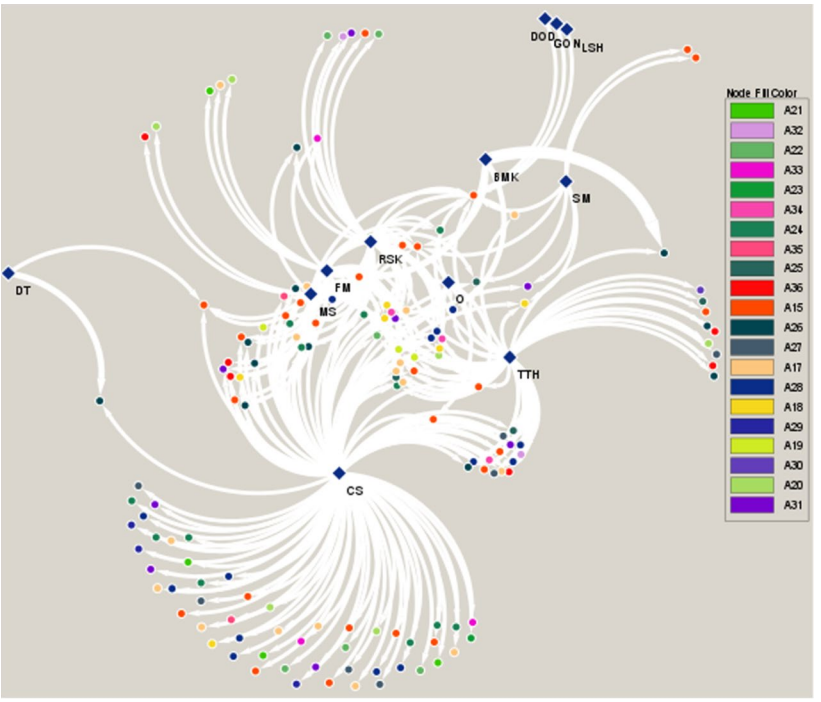
	Agri-Food	Chemic & Para-chemic	Electric & Electronic	Metal-lic & Mechanic	Textile & Leather	Total
Béni Mellal Khénifra	0.39%	0.01%	0.00%	0.11%	0.38%	0.18%
Drâa Tafilalet	0.01%	0.08%	0.00%	0.00%	0.01%	0.03%
Ed Dakhla Oued ed Dahab	3.86%	0.00%	0.00%	0.00%	0.00%	0.62%
Fès Meknès	6.53%	0.12%	0.11%	1.37%	9.20%	3.75%
Casablanca Settat	15.13%	63.90%	50.96%	64.40%	58.56%	52.91%
Guelmim Oued Noun	4.59%	0.00%	0.00%	0.00%	0.00%	0.74%
Laâyoune Saguia al Hamra	4.13%	1.50%	0.00%	0.00%	0.00%	1.19%
Marrakech Safi	18.81%	28.68%	0.05%	0.39%	2.57%	13.87%
Oriental	2.64%	0.08%	0.01%	11.87%	0.41%	1.52%
Rabat Salé Kénitra	7.39%	3.68%	9.01%	3.31%	12.19%	7.29%
Souss Massa	27.10%	0.65%	0.02%	0.38%	0.03%	4.63%
Tanger Tétouan Alho-ceima	9.42%	1.30%	39.84%	18.18%	16.65%	13.26%
Total	100%	100%	100%	100%	100%	100%

Source: Authors

10,000 products while intranational trade concerns, depending on the mode of transport, between 51 and 171 products. To assess the economic complexity of the nine Australian states, Reynolds et al. (2018)[12] relied on the multi-regional input-output table listing 506 products and services exported by Australia in 2009.

To calculate the economic complexity index (ECI) of the regions, we started by establishing a "Region-activity" network (Fig. 2), similar to that relating to the "Country-Product" developed by Hidalgo & Hausmann (2009).

[12] These authors seem to be the first to have used a multi-regional input-output table and taken services into account for the evaluation of economic complexity at the sub-national level.



Source: Authors.

Note: The "Region-Activity" bipartite network (156 nodes and 277 links) connects (existence of a non-zero export RCA) the regions (BMK: Béni Mellal-Khénifra; CS: Casablanca-Settat; DOD: Dakhla-Oued Ed-Dahab; DT: Drâa-Tafilalet; FM: Fès-Meknès; GON: Guelmim-Oued Noun; LSH: Laâyoune-Sakia El Hamra; MS: Marrakech-Safi; O: Oriental; RSK: Rabat-Salé-Kénitra; SM: Souss-Massa; TTH: Tanger-Tétouan-Al Hoceïma) (Diamonds) to the activities (Circles). The link is all the thicker as the RCA is high. Activities are customized in the same way for each sector (A15: Food industries; A19: Leather and footwear industry; A22: Publishing, printing, reproduction; A26: Manufacture of other non-metallic mineral products; A20: Woodworking and manufacture of wooden articles; A28: Metalworking; A18: Clothing and fur industry; A29: Manufacture of machinery and equipment; A27: Metallurgy; A23: Coking, refining, nuclear industries; A34: Automotive industry; A31: Manufacture of electrical machinery; A25: Rubber and plastics industry; A36: Manufacture of furniture, various industries; A17: Textile industry; A33: Manufacture of medical instruments, optical precision and watchmaking; A21: Paper and cardboard industry; A24: Chemical industry; A35: Manufacture of other transport equipment; A32: Manufacture of radio, television and communication equipment; A30: Manufacture of office machines and computer equipment; A37: Recovery)

Fig. 2 Region-Activity bipartite network of industrial exports from Morocco in 2015

This network makes it possible to link the regions to the activities by connections as important as the revealed comparative advantages (Eq. (1) page 4) of a given region in relation to a given industrial activity. Subsequently, we calculated the indices of diversity (Eq. 2 page 4) and ubiquity (Eq. 3 page 5) which are the basis of the construction of the ECI (Eq. 9 page 5). Indeed, the latter is all the more important for a given region if it is diversified, that is to say that it exports in several activities, and that the latter are of low ubiquity, i.e. few regions export there. To calculate the different indicators and matrices needed to assess economic complexity, we used the Econgeo package on R (Balland, 2017).

The three southern regions (top and right of the network) have a sparse network (less diversified regions) while that of Casablanca-Settat has a very dense network (more diversified region). The 51[13] activities at the edge of the network (having low ubiquity) are exclusively exported by a single region while those at the core of the network are exported by a higher number of regions (high ubiquity). [14] Several groups of activity reveal the emergence of an ecosystem around specific industries such as those of the automotive and electrical and electronics industries in Tanger-Tétouan-Al Hoceïma and Casablanca-Settat in the south-east of the region-activities network bringing together several activities revolving around these industries (metalworking (aluminum and steel), electronic components, insulated wires and cables, etc.).

The diversity of regions (Eq. 2 page 4) and the average ubiquity of industries in which the region has a comparative advantage (Eq. 4 page 5) are negatively correlated in 2015 ($\rho = -0.58$ and p-value $= 0.05$) (Fig. 3). Casablanca-Settat has the highest diversity associated with a very low average ubiquity revealing its exclusive specialization in activities less covered by other regions.

On the other hand, the three southern regions record low diversity combined with a high average ubiquity indicating their low specializations which, moreover, in activities widespread in the other regions related to the processing of fishery products. This decreasing link between diversity and ubiquity has also been verified for the Chinese provinces with a slightly greater correlation ($\rho = -0.777$ and p-value $= 2.8.10^{-7}$) (Gao & Zhou, 2018a) and the 50 Spanish provinces (Balsalobre et al., 2019). The significance of this inverted relationship between diversity and ubiquity supports the intuitive construction of the ECI which reveals that the most complex regions are those that manage not only to diversify but also to do so in less ubiquitous activities. Thus, these regions are more competitive and manage to export unusual products, unlike less competitive regions whose export basket does not include a wide variety of activities and which, moreover, are highly ubiquitous.

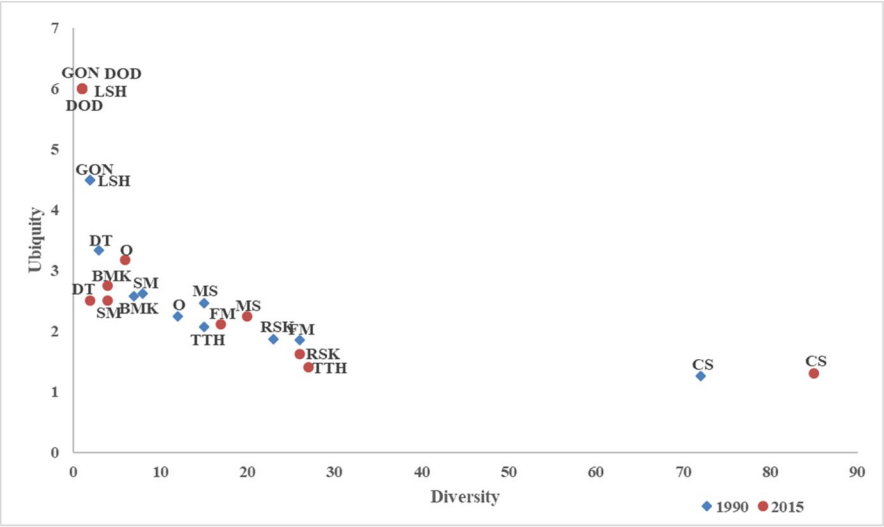
The inverse relationship between diversity and ubiquity is verified over the period 1990–2015. Moreover, the Moroccan regions, and Tanger-Tétouan-Al Hoceima in particular, have improved their diversities by opening their exports to a wider basket of activities while their ubiquities were preserved between 1990 and 2015. Because of this evolution slightly differentiated between the two indices, the negative correlation between diversity and ubiquity was more accentuated in 1990 ($\rho = -0.66$ and p-value $= 0.02$).

We estimated the Economic Complexity Index (ECI) of Moroccan regions by combining information on the ubiquity and diversity indices (Eq. 9 page 5). Casablanca-Settat is the most complex region of Morocco in 2015 surrounded by four regions with upper intermediate complexity (Fig. 4).

These are the one bordering the north on the Atlantic coast, namely, Rabat-Salé-Kénitra and those of the Middle Atlas and its foothills (Béni-Mellal-Khénifra and

[13] Example of the two activities of the food industries, namely the manufacture of animal feed and the manufacture of other oils, at the top and on the right of the network, which are exclusively exported by Souss-Massa in 2015.

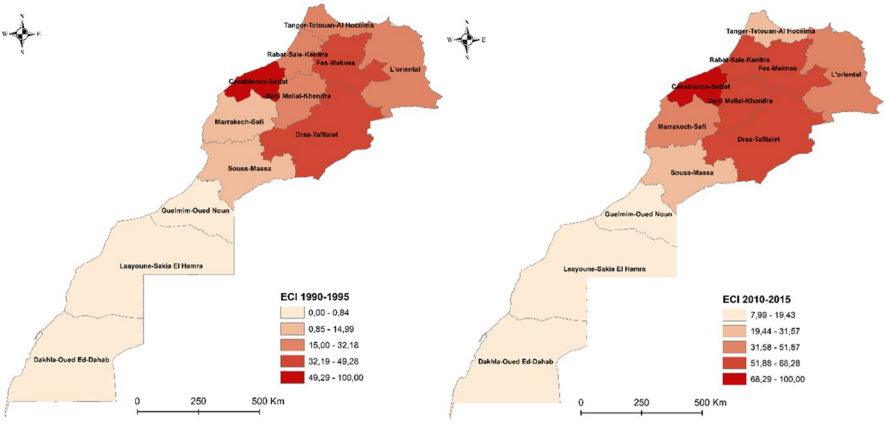
[14] Example of the activity relating to the preparation and canning of fish exported by all nine coastal regions with a much more advantageous RCA for the four regions of the southern Atlantic coast (SM, GON, LSH and DOD).



Source: Authors.

Note: Casablanca-Settat (CS) records high diversity associated with low ubiquity

Fig. 3 Inverse relationship of the ubiquity and diversity of the regions of Morocco in 1990 and 2015



Source: Authors.

Note: Four regions have a ECI median between 52 and 68 in 2010-2015, i.e. a higher intermediate complexity

Fig. 4 Median Economic Complexity Index of the regions of Morocco in 1990–1995 and 2010–2015

Fès-Meknès) and the Ultra-Atlas (Drâa-Tafilalet). Southern regions record relatively low complexities.[15]

[15] The notion of strong or weak is relative to the national context. A standardized database by region at the international level could lead to an absolute comparison of all subnational regions at the global level in the same way as the analysis made for the countries by Hausmann and Hidalgo (Hidalgo & Hausmann, 2009).

This diffusion of complexity, which we have noted from the economic center to the peripheral territories step by step, has also been reported by Gao & Zhou (2018a) in relation to the Chinese coastal provinces which present a higher economic complexity, followed by the provinces located in the southwest and northeast of China. This "spill-over" effect is also highlighted for the Russian regions with a diffusion of complexity starting from the region of the capital Moscow and decreasing as it spreads to the East (Farra et al., 2013). This same type of distribution is noted in Kazakhstan with a high level of complexity in the city of Almaty, former capital and main economic center with 20% of the GNI, which then spreads to the entire province of Almaty then to the capital Astana before spreading to the rest of the country (Farra et al., 2015).

This regional configuration of economic complexity was generally maintained between 1990 and 2015 with, in particular, Casablanca-Settat being the most complex region in Morocco (Fig. 5).

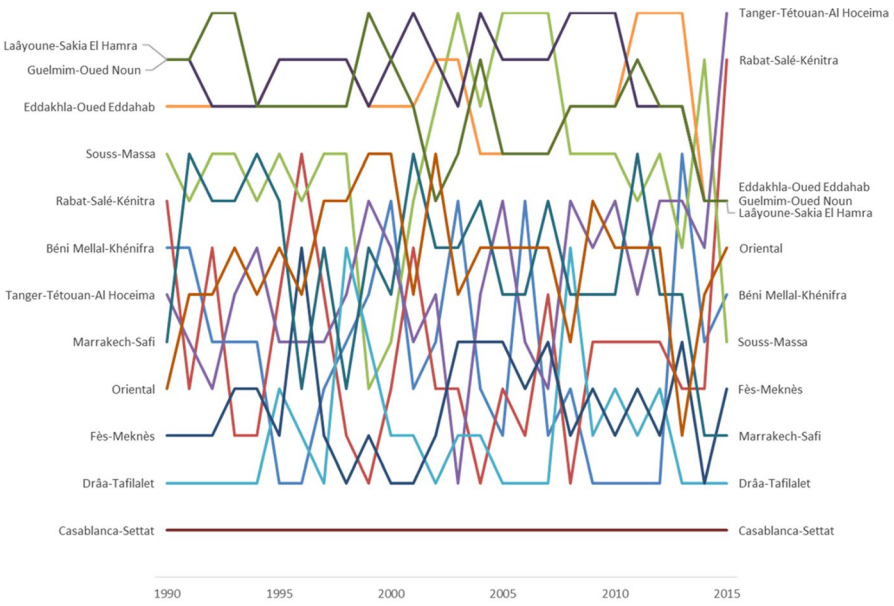
The southern regions took turns being the least complexified regions during the same period (Fig. 6).

Thus, the ECIs of the regions of Morocco in 2010–2015 are positively and significantly correlated with those of 1990–2015 ($\rho = 0.9$ and p-value = 6.8.10-5), reflecting the overall stability of economic complexity. This inertia of the relative level of economic complexity at the territorial level has also been noted for the Chinese provinces ($\rho = 0.898$ and p-value = 7.4.10-12) (Gao & Zhou, 2018a) and for the 50 Spanish provinces (Balsalobre et al., 2019).

The regions of Casablanca-Settat, Oriental, Souss-Massa and Guelmim-Oued Noun, which are placed on the first bisector (Fig. 7), kept their places in the ranking between 1990 and 2015 (respectively, 1st, 7th, 9th and 11th most complex regions of Morocco). The regions that are positioned below have improved their rankings such as Béni Mellal-Khénifra, with +4 ranks, moving from 6th to 2nd place. In addition, those placed above experienced a regression in their complexity such as Tanger-Tétouan-Al Hoceima which lost 3 ranks, dropping from 5th to 8th place.

Relationship Between the Economic Complexity of Moroccan Regions and their Level of Well-Being

Hidalgo & Hausmann (2009) highlighted the predictive quality of ECI regarding the level of development of countries. Thus, they regressed the growth rate of GDP per capita in PPP of a sample of countries on several variants of the ECI controlling by the initial level of GDP per capita in PPP over a period of 20 years. Gao & Zhou (2018a) have also used the robustness of the predictive quality of ECI as a measure of the intangible assets of regional productive systems. Thus, they found a significantly positive correlation ($\rho = 0.667$ and p-value = $4.1.10^{-5}$) between the ECI and the ln (GDP per capita) for the Chinese provinces. Balsalobre et al. (2019) have noted that the ECI is a good medium-term predictor, i.e. a 10-year horizon, of GDP per capita for the 50 Spanish provinces.



Source: Authors.

Note: Casablanca-Settat remained the most complex region of Morocco between 1990 and 2015

Fig. 5 Evolution of the classification of Moroccan regions according to their economic complexities between 1990 and 2015

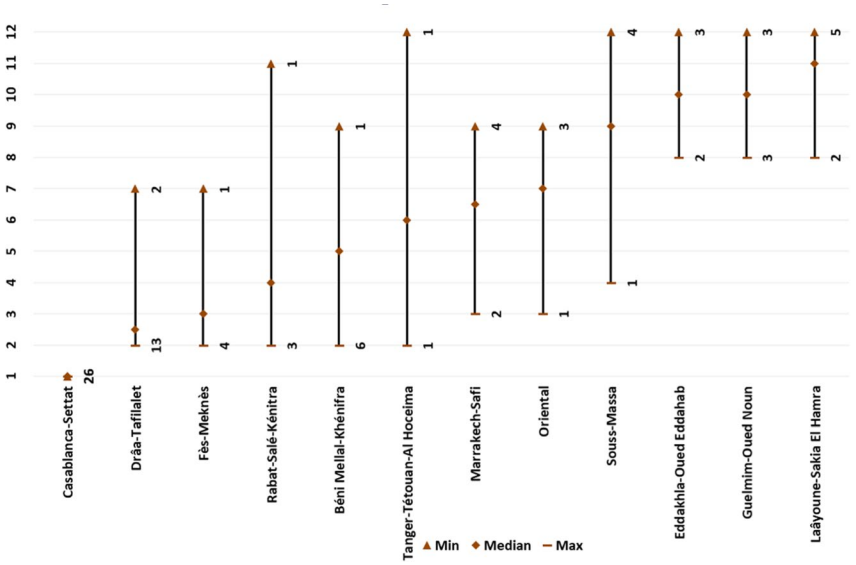
Thus, we found that, for Moroccan regions, the correlation between ECI[16] and well-being is not significant. However, the correlation is significative between the ECI and the economic ($\rho = 0.669$ and p-value $= 0.017$) and social ($\rho = 0.652$ and p-value $= 0.022$) components of objective well-being.

A Principal Component Analysis (PCA) was used to provide a typology of regions according to their economic complexities and their situations of well-being as intangible prerequisites for their emergence, in order to draw conclusions to support their development. The representation qualities are high, which indicates that the components extracted by the PCA represent our variables well (Table 4). This analysis made it possible to draw up a map crossing the themes of well-being with the economic complexity relating to the regions[17] (Fig. 8).

The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy and Bartlett's test of sphericity confirm the suitability of our data for structure detection by PCA. Indeed, the KMO measure (0.553) is greater than 0.50 and Bartlett's test of sphericity is significant at the 5% level (p value $= 0.022$) (Table 6).

[16] Median 2010–2015 to control index volatility for some regions.

[17] This mapping is represented on a synthetic plan summarizing 67% of all the information.



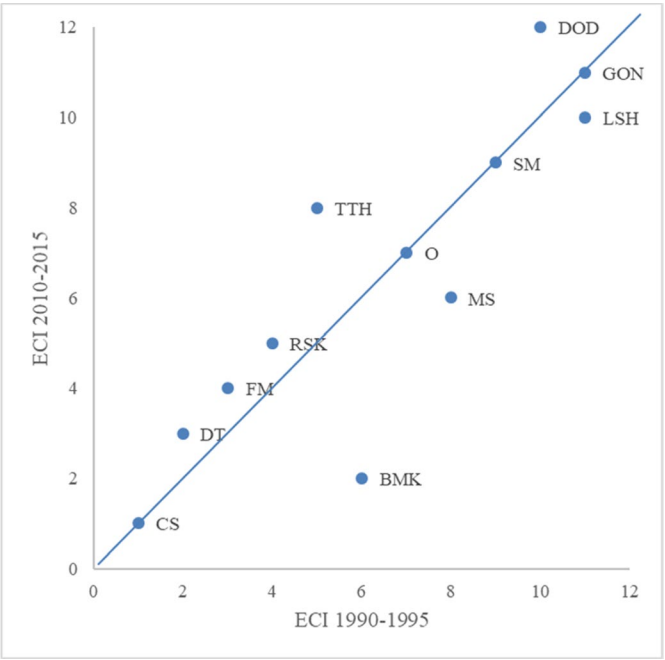
Source: Authors.

Note: Regions are ranked from left to right according to their median ECI rank between 1990 and 2015. Tanger-Tétouan-Al Hoceima has the most volatile ECI, ranking it once last and once second then that his median rank is 6th place

Fig. 6 Extent of the ranking and frequencies of the extreme ranks of the regions of Morocco according to their economic complexities between 1990 and 2015

The first axis represents themes related to socio-economic development associated with high economic complexity (Table 7). Thus, it spreads the regions from left to right according to their level of economic complexity linked to their economic development accompanied by a high level of human capital and advanced innovation improving their living and health conditions with, however, low levels in terms of environment and governance (Fig. 9). This seems to prevail the link between economic complexity and socio-economic development as noted in the literature for both the national and sub-national scope.

Indeed, a positive relationship between economic complexity and human development has been noted (Ferraz et al., 2018) as well as health performance (Vu, 2020). However, this economic complexity associated with high level of socio-economic development is reflected by a deterioration of the environment of the regions and is linked to a weak level of governance. This finding is consistent with other studies that have concluded that economic complexity increases the ecological footprint, suggesting increased investment in renewable energy and energy efficiency (Rafique et al., 2022), especially for low-income and middle income countries (Doğan et al., 2019). Furthermore, our observation concerning governance argues for an improvement in the quality of institutions, which has a positive effect on economic complexity in particular and ultimately reduces the persistence of underdevelopment (Vu, 2022).



Source: Authors.

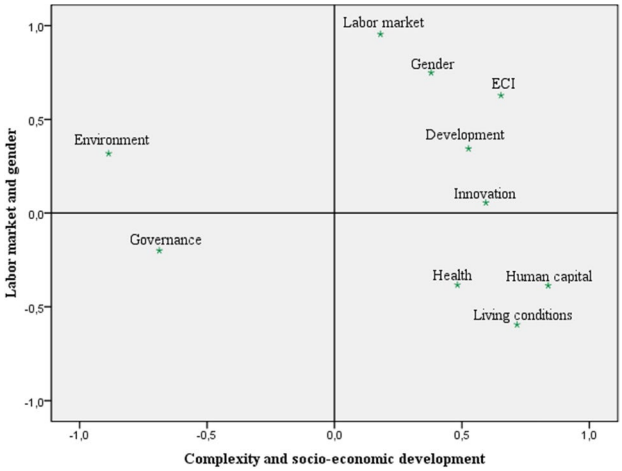
Note: The first bisector separates the regions that improved their rankings between 1990-1995 and 2010-2015 (below) from those that regressed (above)

Fig. 7 Stability of the ranks of Moroccan regions according to the ECI between 1990 and 2015

As for the second axis, it represents, in its upper part, the regions with an accommodating labor market and less significant gender inequalities. Thus, in our case, the reduction of gender inequalities does not seem to be linked to economic complexity. However, the latter seems to reduce gender inequalities in primary and secondary education, regardless of the country's income level, and in the higher education for middle-income countries (Ben Saâd & Assoumou-Ella, 2019).

The distribution of the regions on this factorial plan makes it possible to restore a cartography of the latter according to the state of their socio-economic development and their economic complexity and this, according to three homogeneous groups:

– *Regions combining socio-economic development and economic complexity:* These are the regions of Casablanca-Settat and Rabat-Salé-Kénitra and for which the link between economic complexity and socio-economic development seems to prevail as noted in the literature both for the national perimeter than subnational.
– *Regions having begun a semblance of economic complexity but with a level of socio-economic development below potential*: These are the regions of Tanger-Tétouan, Fès-Meknès, Souss-Massa and to a lesser extent Oriental, Marrakech-Safi, Beni-



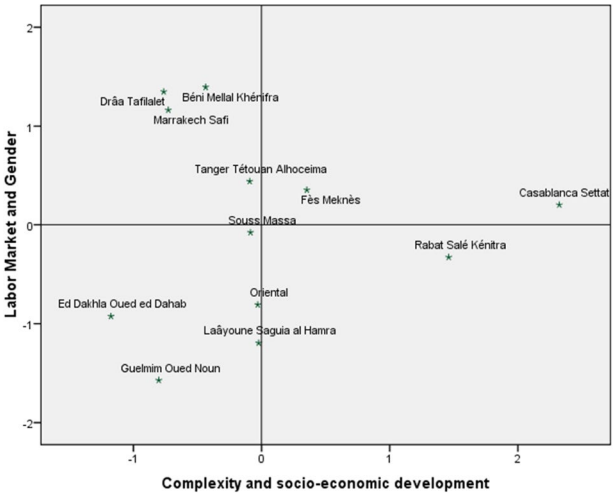
Source: Authors and (Boumahdi & Zaoujal, 2023).

Note: Synthetic plan, summarizing 67% (Table 5) of all the information, made up of the abscissa axis, which opposes the indicators relating to economic complexity and certain socio-economic themes (human capital, living conditions, innovation and development) and the y-axis, which represents the indicators of the Labor Market and Gender themes

Fig. 8 Relationship between economic complexity and well-being themess

Mellal-Khénifra and Drâa Tafilalet. This case has been noted in the analyses established at the national level showing that countries, such as China and Thailand, which have a level of economic complexity higher than that which corresponds to their level of per capita income (Hausmann et al., 2014), have higher growth margins than those with a level of income that actually corresponds to their complexity. Also, it is necessary to better direct these signals of under-exploited collective knowledge for these regions in order to raise their socio-economic levels in the future.

– *Regions with low economic complexity but recording high socio-economic development*: These are the southern regions of Laâyoune-Sakia-El-Hamra, Dakhla-Oued Ed-Dahab and Guelmim-Oued Noun, taking into account the link of the productive system of these regions to natural resources, fishing and mining, and the special attention given by the State to better equip these regions in terms of socio-economic equipment but which does not yet seem to have any influence on the complexification of the local productive fabric. This configuration has been noted in analyses at the national level indicating that countries, such as Qatar, Venezuela and Kuwait, which have a very high level of per capita income have a very low economic complexity (Hausmann et al., 2014). This is due to the high concentration of their exports on natural resources. Also, it is necessary to better consolidate the productive knowledge of these regions in order to diversify and complexify their productive system.



Source: Authors and (Boumahdi & Zaoujal, 2023).

Note: The regions are arranged from left to right according to their levels of complexity and socio-economic development and from bottom to top according to their levels with respect to labor market and gender themes

Fig. 9 Typology of regions according to their levels of economic complexity and themes of well-being

Conclusion

The accumulation and transfer of knowledge are increasingly becoming an essential determinant in the catch-up of developing countries, based on the knowledge economy. This intangible vector of production is echoed in the complexity of the goods and services offered by the territories. However, the limits imposed by information, already at the national level, have pushed to adopt the intuitive approach that foreign trade would reflect the complexity of the productive fabric of a nation, and therefore of its degree of cognitive development (Hausmann et al., 2014).

The intuition developed consists of considering that countries increase their level of complexity when they are able to produce a diversified range of goods that very few countries produce. As much as the application to the national context has been largely established, the extension of this intuition to the subnational context has been very limited. The application to the Moroccan context falls within the framework of these avant-garde attempts aimed at enriching the international experience on this subject and establishing intelligent strategies capable of contributing to the emergence of competitive regional productive fabrics capable of succeeding in their integration into an increasingly open global economy and rapid structural change.

At the end of our analysis, it turns out that the regions of Morocco form a space-product network around nuclei of different densities illustrating productive systems of such different maturities. This reveals the emergence of ecosystems around complementary activities leading to an increase in the complexity of the regions associated with them (example of the ecosystem of automotive industries in Tanger-Tétouan-Al Hoceïma and Casablanca-Settat).

Regions of high complexity present high diversity combined with low ubiquity, i.e. exclusive exports on activities little covered by other regions. This regional dynamic was maintained between 1990 and 2015 with a stable ubiquity of the regions associated with a slight improvement in their diversity.

As observed in the few countries that have adopted this approach at the territorial level[18], complexity spreads from the economic capital Casablanca-Settat to neighboring regions with high intermediate complexity (Rabat-Salé-Kénitra, Fez-Meknes, Beni Mellal- Khénifra and Drâa-Tafilalet) then those adjacent with a low intermediate complexity (Tangier-Tétouan, Marrakech-Safi, the Oriental and Souss-Massa) before extending to other southern regions with low complexity.[19]

This analysis also made it possible to draw up a typology of regions crossing their levels in relation to the themes of well-being and their economic complexities (Table 3). It turns out that a high level of economic complexity is linked to such high economic development accompanied by qualified human capital and advanced innovation improving their living and health conditions with, however, low levels on the environment and governance plan[20].

Thus, despite the limits of the approach (restrictions to goods apart from services, restrictions to exported goods apart from domestic ones, relative analysis in the absence of an international database of regional exports[21], analysis restricted to two components instead of three components for better readability of the results, etc.), the analysis has made it possible to identify certain avenues for improving the complexity of the regions that seem to be emerging:

- *Intensify the mesh between industrial activities:* Regions active in industrial ecosystems made up of complementary branches manage to improve their economic complexities and their diversifications[22] calling for the implementation of local industrial development strategies.[23]

- *Intensify the interregional network:* The spatial diffusion of regional complexity calls for the convergence of local industrial development strategies in order to

[18] This same center-peripheral diffusion of complexity has been noted for the Chinese (Gao & Zhou, 2018a), Spanish espagnoles (Balsalobre et al., 2019), Russian (Farra et al., 2013), and Kazakh (Farra et al., 2015) provinces.

[19] The notion of strong or weak is relative to the national context and could only be extended internationally in the presence of a standardized database by region at the international level, like the first test made for the Russian and Kazakh regions (Farra et al., 2015).

[20] At the supranational level, countries exporting complex products have lower levels of inequality than countries exporting simpler products. The same is true at the sub-national level (Hartmann et al., 2017). The economic complexity of Chinese provinces has a negative effect on regional income inequalities estimated by the ratio of relative income in an urban region to that of a rural region (Gao & Zhou, 2018b).

[21] The creation of a community database on bilateral international trade between all the equivalent subnational entities in each country in the world following a very fine disaggregation of products, would be likely to better draw lessons from the complexity at the territorial level. An attempt was made based on a joint matrix of revealed comparative advantages of Russia and Kazakhstan (Farra et al., 2015).

[22] The likelihood of a province developing a new industry increases with the number of related industries already present in that province (Gao et al., 2017).

[23] Policies for the active industrialization of territories are often cited as major levers for their structural transformations (Mokri, 2016).

Table 3 Performance of the regions on the aspects of economic complexity and themes of well-being

Region	Economic compleity		ECI	Economic				Economic Synthetic Index	Social			Social Synthetic Index	Environnement	Governance	Well-being Synthetic Index
	Diversity	Ubiquity		Development	Human Capital	Labor market	Innovation		Living conditions	Health	Gender				
Casablanca Settat	85	1,3	100	35,7	57,2	53,8	0,9	36,9	18	41,2	45,9	35	0	16,5	22,1
Rabat Salé Kénitra	26	1,6	60,3	16,9	51,7	49,1	4	30,4	18	35,1	39,4	30,8	26,5	25	28,2
Béni Mellal Khénifra	4	2,8	68,3	27,9	40,5	58	0,2	31,6	11,6	37,8	44,1	31,2	81,6	37,6	45,5
Drâa Tafilalet	2	2,5	67,9	8,6	43,8	54,9	0,4	26,9	11,6	22,3	53,3	29,1	73,1	45	43,5
Fès Meknès	17	2,1	66,2	12,4	50,2	50,6	0,5	28,4	13,8	30	44,9	29,6	35	30,8	30,9
Marrakech Safi	20	2,3	51,9	14	40	59,3	0,6	28,4	12,5	30,1	42,2	28,3	77,3	39	43,3
Oriental	6	3,2	47	5	48,9	41,8	0	23,9	14,7	37,6	26,7	26,3	51,9	23,1	31,3
Tanger Tétouan Alhoceima	27	1,4	31,6	32,6	46,5	53	0,3	33,1	14,2	27,2	32,4	24,6	66,7	24,3	37,2
Souss Massa	4	2,5	28,6	17,4	43	47,8	0,5	27,1	16,6	31,9	42,9	30,5	57,2	29,8	36,1
Laâyoune Saguia al Hamra	1	6	19,4	21,6	50,9	39,8	0	28,1	15,9	45,9	39,2	33,7	48,7	55	41,4
Guelmim Oued Noun	1	6	17,8	2,9	46,7	39,8	0	22,4	16	36,8	16	22,9	61,4	48	38,7
Ed Dakhla Oued ed Dahab	1	6	8	13,1	43	39,8	0	24	13,6	23,4	16	17,7	57,2	41,6	35,1

Less performing → More performing

Source: Authors and (Boumahdi & Zaoujal, 2023)

create synergies to trigger constructive territorial competitiveness in favor of a diversified transregional or even cross-border value chain[24]. The role of metropolises and agglomerations of different sizes is important in such a network in order to align functional and infrastructure allocations in an optimal way with territorial development objectives.

- *Strengthen intra and inter-regional connectivity:* Infrastructures favoring material and immaterial flows densify inter-industrial and inter-regional networking and improve local comparative advantages. [25]

- *Improve the human capital of the regions:* the complexity of a region is linked to the level of its human capital, calling for the alignment of local reforms relating to education, training and innovation with the prospects for industrial development local. Particular attention should be given to the qualification of women and their professional integration. [26]

[24] The probability that a province develops an industry increases with the number of neighboring provinces that are developed in this industry (Gao et al., 2017).

[25] Provincial industries increased their productivity when connected by rail to other provinces where this industry was already present (Gao et al., 2017).

[26] Empirical studies in the literature have little or not studied the relationship between complexity and gender equality, but signs to be explored between industrialization, observed in the case of the most complex Moroccan regions, and gender equality have been vaguely identified (Hartmann et al., 2017).

Appendix

Table 4 Quality of representation of PCA

	Initial	Extraction
ECI	1000	823
Development	1000	576
Human capital	1000	860
Labor market	1000	944
Innovation	1000	660
Life conditions	1000	873
Health	1000	800
Gender	1000	738
Environment	1000	893
Governance	1000	635

Source: Authors

Table 5 Eigenvalues and Total variance explained by PCA

Component	Initial eigenvalues			Extraction Sums of the squares of the factors retained		
	Total	% of variance	% cumulative	Total	% of variance	% cumulative
1	3938	39,379	39,379	3938	39,379	39,379
2	2780	27,795	67,174	2780	27,795	67,174
3	1083	10,831	78,006	1083	10,831	78,006
4	800	8000	86,005			
5	628	6277	92,282			
6	382	3820	96,102			
7	210	2104	98,205			
8	098	984	99,190			
9	057	571	99,761			
10	024	239	100,000			

Source: Authors

Table 6 KMO index and Bartlett test of PCA

Measuring precision of Kaiser-Meyer-Olkin sampling.		553
Bartlett's test of sphericity	Approximate chi-square	65961
	df	45
	Bartlett's significance	022

Source: Authors

Table 7 Component matrix

	Component	
	1	2
ECI	653	629
Development	526	344
Human capital	838	−387
Labor market	180	955
Innovation	594	055
Life conditions	716	−595
Health	482	−383
Gender	379	749
Environment	−886	318
Governance	−687	−199

Source: Authors

Declarations

Ethics Approval This research study is in agreement with ethical standards as contained in the Committee on Publication Ethics guidelines. For this type of study, ethical approval is not required, as the data used didn't involve human or animal participants.

Consent to Participate For this type of study, informed consent is not required.

Conflict of Interest On behalf of all authors, the corresponding author states that there is no conflict of interest.

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