INEQUALITIES BETWEEN MEDITERRANEAN COUNTRIES ON THE NORTH, SOUTH AND EAST SHORES: A MULTIDIMENSIONAL ANALYSIS[1]

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Abstract. The present study analyzes the inequalities between countries on the North, South and East Mediterranean shores. These geographic areas exhibit different socio-demographic and economic structures, health, and employment status, and unequal access to technological and environmental opportunities. The multidimensional analysis herein presented is carried out along the main key policy areas of the New Agenda for the Mediterranean: a) Human development, b) Economic resilience, prosperity and digital transition, c) Green transition, climate resilience and energy. This research rises under the context of WeMed, a joint project between Istat and CNR that offers an integrated analysis of the social, economic, environmental, and gender dynamics of Mediterranean countries. The WeMed database is the result of a complex process of collection, comparison, and selection of indicators from the most accredited international sources (World Bank, United Nations, ILO, IMF, OECD, Eurostat and Istat). Using Principal Component Analysis (PCA) and Cluster Analysis (CA), the study identifies underlying dimensions and classifies 25 countries into four clusters. The main findings, based on multivariate methods, reveal consistent geographical patterns and atypical national profiles, highlighting the need for diversified, shore-specific policy approaches.

1. Premise

Over the past decade, the Mediterranean basin has undergone a process of convergence, despite persistent inequalities among the countries of its Northern, Southern, and Eastern shores. This convergence has been more evident in socio-demographic dimensions than in economic or environmental ones (Doignon, 2023, Trimarchi, 2008).

Since 2021, the European Commission and the High Representative have presented a joint Communication proposing the launch of a new Agenda for the Mediterranean, aimed at outlining the priorities and framework of the EU's policy towards the Region with a view to a strengthened partnership. The Agenda focuses on five areas of intervention: 1) *rule of law and human development*, supporting

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democracy and good governance, strengthening the preparedness and resilience of health systems; promoting the empowerment of youth, civil society and gender equality; 2) *resilience, prosperity and digital transition*, restoring confidence in the business environment by encouraging economic diversification, supporting the digital transition in both public and private sectors, and advancing women's economic empowerment; 3) *peace and security*, assisting countries in addressing security challenges and finding solutions to ongoing conflicts; 4) *migration and mobility*, intensifying cooperation on migration through comprehensive, tailor-made partnerships adapted to each country's needs; 5) *green transition, climate resilience, energy and environment*, protecting natural resources and fostering green growth, in line with the objectives of the European Green Deal and climate neutrality by 2050.

This paper focuses on three of these priority areas - Human development (1), Digital transition (2), Green transition (5) - selecting key indicators aligned with the strategic initiatives outlined in the Agenda (see Table 1). A multidimensional analysis was conducted to produce country clusters offering a classification that reflects diverse structural profiles.

The concept of inequality is addressed from a multidimensional perspective. While economic conditions remain a fundamental component, they are not sufficient on their own to ensure the structural reduction of disparities (Capasso and Canitano, 2024). Sustainable development requires simultaneous progress in social, environmental, and cultural dimensions (UNDP, 2024). The living conditions of disadvantaged populations can only improve sustainably through systemic change - particularly in areas that are crucial to individual and collective well-being, such as education and access to essential services. The ambition of the 2030 Agenda is to reduce "all forms of inequality" through an integrated approach guided by its 17 Sustainable Development Goals (SDGs), with Goal 10 being central to this effort (ASviS, 2019).

2. Key indicators and main sources of the Mediterranean New Agenda

The Economic Investment Plan accompanying the Mediterranean Agenda includes flagship initiatives aimed at stimulating long-term socio-economic recovery in the Southern Neighbourhood.

These initiatives are designed to be implemented at both national and local levels, with a strong focus on sustainability, inclusion, and resilience (PCM, 2024). To monitor progress and align with strategic priorities, a set of key indicators has been selected and organized according to the Agenda's main areas of intervention (see Table 1).

These indicators - sourced from official international databases - have been processed for 25 countries across four macro-regions, and along three Mediterranean shores.

Table 1 – *Key indicators classified by priority of the New Mediterranean Agenda*.

Priority	Flagship Initiatives	Key Indicators	Sources
1.HUMAN DEVELOPMENT	1.1 Promoting youth empowerment and gender equality	1.1.1 Age dependency ratio, young (% of working-age population) - S_DPND_YG	UNPD, Istat
		1.1.2 Share of youth not in education, employment, or training (% of youth population) - S_NEET	ILO, Istat
	1.2 Encouraging culture and education	1.2.1 Average years of schooling (pop. >25 years) - S_AY_SCH	UNDP
	1.3 Strengthening the response of health systems	1.3.1 Life expectancy at birth, total (years) – S_LE00	UNDP, Eurostat, Istat
	1.4 Improving living conditions	1.3.2 Mortality rate, infant (per 1,000 live births) - S_IMRT	UN IGME, Istat
2.RESILIENCE, PROSPERITY AND DIGITAL TRANSITION	2.1 Strengthening the business environment	2.1.1 GNI per capita – R_GNP	WB ICP, Eurostat-OCSE
	2.2 Increasing private and public sector digitisation	2.2.1 Fixed broadband subscriptions (per 100 people) – R_BBND	ITU, WBDI
	2.3 Emancipating female employment	2.3.1 Employment to population ratio, 15+ (%) - R_EMP_TOT	ILO, Istat
	2.4 Encouraging economic diversification	2.4.1 Employment in services (% of total employment) – R_SRV_EMPL	ILO, Istat
		2.4.2 Medium and high-tech manufacturing value added (% manufacturing value added) – R_MNF_TECH	UN IDO
3.GREEN TRANSITION, CLIMATE AND ENERGY	3.1 Protecting the natural resources of territories	3.1.1 Fertilizer consumption (kilograms per hectare of arable land) – T_CON_FERT	FAO
		3.1.2 Terrestrial protected areas (% of total land area) – T_LND_PTLD	UNEP WCMC
	3.2 Promoting sustainable food systems	3.2.1 Water productivity (constant 2015 US$ GDP per cubic meter of total freshwater withdrawal) – T_GDP_WP	FAO, AQUASTAT data, WB, and OECD GDP estimates
	3.3 Supporting challenges to climate change	3.3.1 PM2.5 air pollution, mean annual exposure (micrograms per cubic meter) – T_PM25	GBDCN
	3.4 Promoting energy from renewable sources	3.4.1 Renewable energy consumption (% of total final energy consumption) – T_RNEW	IEA, IRENA, NSD, WB, WHO

Source: elaborations on European Commission (2023) and WeMed project (2024).

A multidimensional analysis was performed to assess differences and similarities among these countries (see Sections 3, 4, and 5). The selection of indicators was further informed by the 2023 Joint Communication on Renewing the Partnership with the Southern Neighborhood (European Commission, 2023), which outlines several strategic directions:

- Prioritizing poverty reduction through inclusive education strategies and improved access to education for youth and women;
- Ensuring food security by establishing a sustainable framework under the Food and Resilience Facility, supporting less input-intensive, and rooted farming practices;
- Fostering innovation and entrepreneurship, with a focus on start-ups in healthcare, renewable energy, artificial intelligence, and education.

3. The analysis strategy

The analysis strategy followed in the study consists of two steps. In a first stage, Principal Component Analysis (PCA) was used to obtain a rough preliminary overview of the distribution of the 25 countries in the 15-dimensional space of the standardized individual indicators in a lower-dimensional space. As is known, PCA is a multivariate statistical technique for reducing the dimensionality of a dataset by minimizing the loss of information. This result is achieved by replacing a set of correlated variables with a smaller set of uncorrelated variables, called principal components, which are linear combinations of the original variables and retain most of the total variance (the first component has the highest variance, the second has an immediately lower variance, and so on) (Jolliffe, 2002). In the space of the first three principal components, each point has been coloured differently depending on the geographical area (European Union, Western Balkans, Middle East, North Africa) to easily identify the countries that differ significantly from the others in each area. This visualization allows us to detect outliers and assess how similar countries in the same area are in terms of the considered indicators.

In the second stage, the 25 countries were divided into 4 clusters based on the 15 standardized individual indicators, using a hierarchical and a non-hierarchical clustering method, which led to the same result and confirmed the robustness of the clusters.

In the hierarchical approach, we used the Ward method, which builds a hierarchy of clusters, usually represented using a dendrogram, by minimizing the sum of squared errors (SSE)[2] within the clusters at each step. For this reason, it is considered the most suitable agglomerative method for quantitative variables.

[2] SSE is the sum of the squared Euclidean distances of each point to its respective clusters centroid.

In the non-hierarchical approach, we used the *k*-means method, a partition method that divides the countries into *k* clusters, where *k*=4, to minimize the SSE. Therefore, the two methods minimize the same metric, but the algorithms are very different (Everitt *et al.*, 2011).

The 'empirical' classification based on the individual indicators was then compared with the 'theoretical' classification based on the geographical area to assess how similar countries in the same territory are in terms of the main key policy areas.

The association between the two classifications (i.e., the two nominal variables with 4 categories forming a two-dimensional contingency table) was assessed using the Cramér's V, which varies from 0 (corresponding to no association) to 1 (complete association) (Everitt and Skrondal, 2011).

The formula is as follows:

$$V = \sqrt{\frac{\chi^2 / n}{k-1}}$$

where χ^2 is the Pearson's chi-square, n is the number of countries (25) and k is the number of clusters/geographical areas (4).

4. Findings from the Principal Component Analysis

In order to reduce information redundancy, PCA was applied, from which three principal factors emerged, useful to better interpret the data and to highlight possible clusters through their graphical representation.

Prior to proceeding with the PCA, an outlier analysis was conducted, and the suitability of the dataset was checked by the Kaiser-Meyer-Olkin (KMO) test, which returned an overall value of 0.77, indicating an adequate compactness of the data, and the Bartlett's sphericity test, with a p-value of 2.007×10^{-32}, confirming the presence of significant correlations between the individual variables.

The number of components to be included in the final model was determined using the Kaiser criterion, keeping the components with an eigenvalue greater than 1. The three selected factors together explained just over 80% of the total variability of individual indicators.

The scatter plot of the first two principal components shows clusters of countries based on the dimensions of socioeconomic progress and low-sustainability economic growth (Figure 1). The clear separation between blocks (EU, North Africa, Middle East, Balkans) indicates a good discriminating capacity of the first two principal components.

Table 2 – *Principal Component (PC): label and the highest loadings.*

Component	Label	High-loading variables	Interpretation
PC1	*Socioeconomic development and general welfare*	+ Income, broadband, life expectancy, protected land areas, employment – NEET, Infant mortality	It differentiates more developed and healthy territories, with better environmental and economic conditions, from less developed ones, with higher unemployment, youth distress and mortality rates
PC2	*Economic dynamism with low sustainability*	+ Water productivity, youth dependency ratio, service employment, fertilizer consumption – Renewable energy consumption	It contrasts growing and dynamic areas, with high water productivity, urbanization, and intensive agriculture, with areas that rely more on green energy and have less intensive agriculture
PC3	*Intensive agriculture with environmental impacts and signs of sustainable transition*	+ Fertilizer consumption, education, pollution (PM2.5), renewable energy consumption	It highlights territories with high agricultural productivity, but environmental contradictions accompanied by changing social dynamics

The Mediterranean countries are not distributed randomly but reflect consistent patterns: the EU represents advanced development with sustainability challenges; the Middle East and North Africa show low socio-economic development, with North Africa more sustainable and the Middle East more economically dynamic (Audi, 2022). The Balkans are characterized by a lower youth dependency ratio and a less intensive production, but with a greater orientation towards sustainability than the Middle East. Israel, although in the Middle East, is close to the European model in terms of socio-economic development. It is described by high production intensity, but with reduced orientation towards sustainability. Turkey is positioned closer to the Balkans, also reflecting its ambivalent geopolitical and historical position between Europe and Asia. Egypt shows signs of economic and demographic growth, but still depends on unsustainable practices, thus approaching the Middle Eastern profile.

The scatter plot of the first and third principal components clearly shows four distinct groups with different levels of socio-economic development and agricultural approaches (Figure 2). The EU countries have high socioeconomic development and moderate agricultural patterns, some with early signs of sustainable transition.

Figure 1 – *Scatter plot of the first and second principal components.*

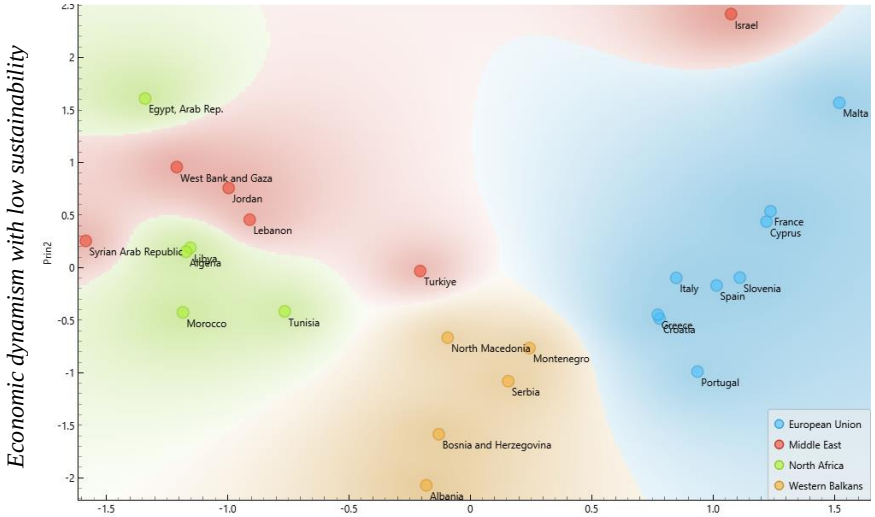
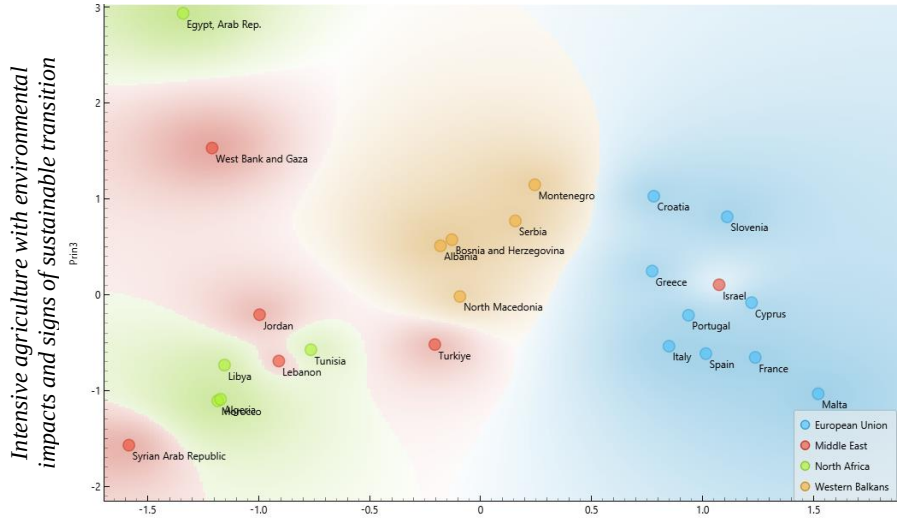


Figure 2 - *Scatter plot of the first and third principal components.*



An intermediate level of socioeconomic development is observed in the Western Balkan countries, which are associated with medium to high intensity agricultural practices. The North African countries are characterized by a low level of socioeconomic development and low agricultural intensity. A notable exception is

Egypt, which has the highest value on the third principal component. This result suggests a highly intensive agricultural model, associated with significant levels of air pollution, but also with a moderate openness towards education and the use of renewable main energy sources. Finally, the Middle Eastern countries are contrastingly positioned. Their location in the graph shows that structural similarities do not always agree with geographical affiliation. Palestine has intensive and sustainable agriculture but low socioeconomic development; Israel is more aligned with the EU model, both in terms of development and agricultural sustainability. Syria is in a critical position on both axes. Jordan and Lebanon are two countries that share structural characteristics like North African countries more than to their Middle Eastern neighbors. Turkey has socio-economic and structural characteristics that make it close to the Western Balkan countries.

5. Cluster analysis results

Since the variance explained by the first three components is only about 80%, it was decided to use all variables for the CA. The analysis with the hierarchical approach (Ward) on the 15 standardised indicators produced the dendogram in Figure 3, that suggests a cut with an R^2 equal to 0.695 and a partition into four groups. A non-hierarchical analysis was also performed using the k-means method where k=4, that produced the same grouping of territories. The silhouette statistics[3] have been computed for each cluster, showing an overall average of 0.315 and values for the first 3 clusters close to the average; only the last group has a very low value (0.1725).

The characteristics of the 4 groups obtained by cluster analysis can be deduced from Table 3, which presents the average values of the indicators in the groups. The first group includes Western European countries with high socio-economic and environmental performance; the second cluster comprises moderately developed countries belonging to Western Balkans with indicators on average compared to other clusters; the third group includes low socio-economic development countries, belonging to North Africa or the Middle East (well defined cluster, Figure 4); the fourth group comprises countries with a very weak socio-economic profile and critical environment (less cohesive cluster composed by two countries).

[3] The statistics (Rousseeuw. 1987) is implemented by calculating the silhouette value for each data point and averaging the result over the entire dataset. The silhouette value for a single data point is calculated using the following equation: Silhouette = $(AverageOut - AverageIn)/\max(AverageOut, AverageIn)$. Where AverageOut is the minimum average distance between the data point and data within other clusters, and AverageIn is the average distance between the data point and other data within the same cluster.

Figure 3 – *Dendrogram of hierarchical clustering by Ward's method and Silhouettes plot with k = 4.*

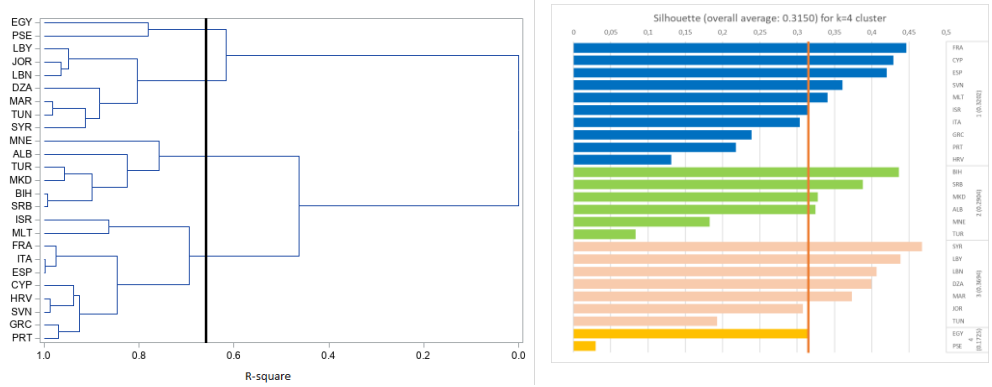


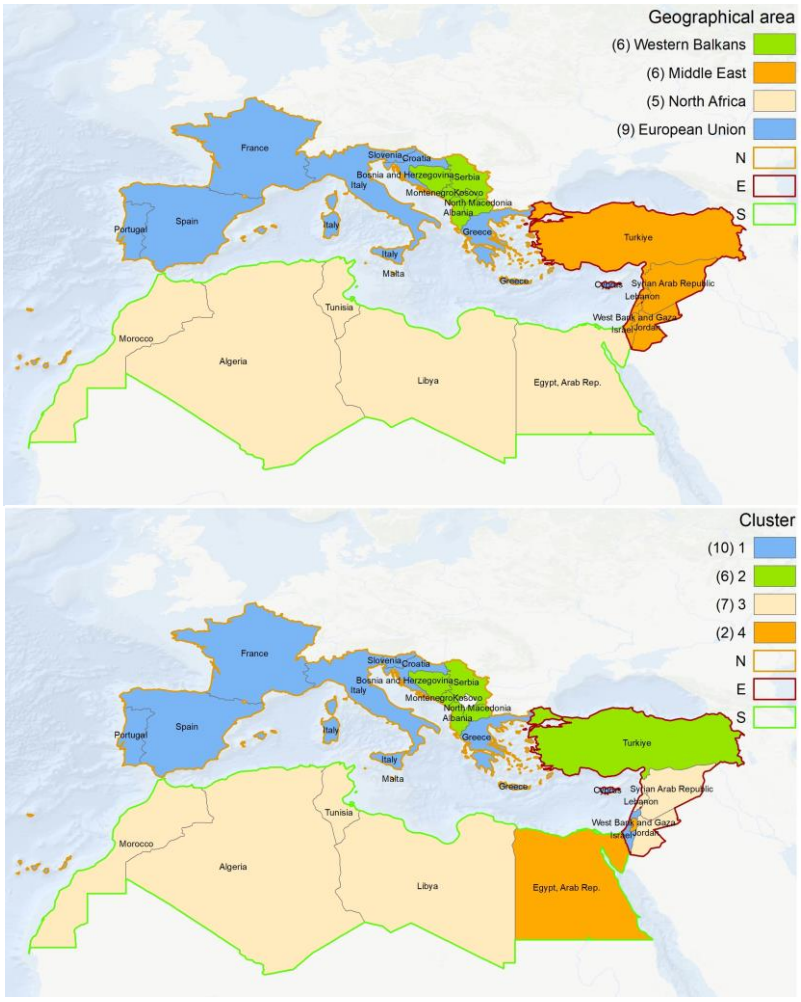
Table 3 – *Silhouette and average values of the individual indicators by clusters.*

Statistics/ Individual indicators	Overall	Cluster			
		1	2	3	4
Size	25	10	6	7	2
Silhouette	0.3150	0.3202	0.2904	0.3694	0.1725
S_DPND_YG	33.0	24.3	26.7	43.3	59.1
S_NEET	19.0	10.5	18.9	28.6	27.5
S_LE00	77.4	81.6	76.1	74.2	71.8
S_IMRT	7.5	3.0	5.5	13.9	13.9
S_AY_SCH	10.2	11.7	10.6	7.7	9.9
R_GNP	27,817	45,773	23,742	10,435	11,105
R_BBND	24.9	38.2	26.9	8.4	9.9
R_EMP_TOT	46.5	54.3	47.7	37.2	36.8
R_SRV_EMPL	66.1	74.7	57.4	63.7	56.9
R_MNF_TECH	25.9	36.1	21.8	18.7	13.0
T_CON_FERT	134.9	150.5	98.2	52.6	455.0
T_LND_PTLD	16.8	30.9	11.2	3.1	10.8
T_GDP_WP	60.0	118.4	24.3	17.2	25.2
T_RNEW	17.5	19.4	29.5	6.4	10.8
T_PM25	20.8	13.1	21.8	25.2	40.6

The comparison between the "theoretical" classification of territories, based on geographical area, and the statistical classification, based on individual indicators (cluster analysis), showing a good but not obvious overlap and interesting anomalies referred to some countries when compared with profiles by geographical area (Figure 4): all EU countries are contained in the first cluster, which also comprises Israel;

the Balkans coincide with the second cluster; the countries of the Middle East and North Africa are divided between the third and fourth clusters. A strong association between the two classifications was observed, as indicated by a Cramér's V of 0.7377.

Figure 4 – *Geographical area and shore classifications compared to statistical clusters.*



6. Final considerations

Based on the results of the multidimensional analysis, this paper proposes a set of policy directions, tailored to the specific profiles of each cluster:

- *Cluster 1* - European Union: consolidate socio-economic performance; address challenges related to ageing, environmental sustainability, and intergenerational equity.
- *Cluster 2* - Balkans and Turkey: support convergence processes with the EU, strengthen education, digitization, and youth inclusion.
- *Cluster 3* - North Africa/Middle East: promote investment in human capital, basic public services, with a focus on sustainability in agriculture and energy use.
- *Cluster 4* - Egypt and Palestine: urgent need for international cooperation and targeted assistance, focusing on health, environment, and demography.

Beyond the specific clusters, the analysis reveals: partial convergence across Mediterranean shores, especially in demography; growing internal diversity within macro-areas, with some countries exhibiting "structurally ambiguous" behavior (e.g., Israel aligns with EU; Albania deviates from the Balkan profile). The statistical classification (via CA) aligns well with the geographical framework.

The next phase of the research will evolve under the ISTAT–CNR partnership within the WeMed project (Abate *et al.*, 2024). It will:

- develop new geo-statistical tools and metadata systems to monitor territorial inequalities across a consolidate set of indicators.
- Inform integrated, multi-level policy actions that reflect complex realities in the Mediterranean region.
- Foster sustainable, equitable, and cooperative development, also aligned with the Sustainable Development Goals.

Finally, this framework reaffirms that reducing Mediterranean disparities requires context-specific, multidimensional strategies and the continuous integration of empirical evidence into policy design.

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