

## **REGIONAL DISPARITIES AND SOCIAL DEPRIVATION IN SPAIN: A NUTS2-LEVEL ANALYSIS USING THE DP2 METHODOLOGY**

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**Abstract.** Between 2019 and 2023, Spain faced a sequence of major socioeconomic shocks, including the COVID-19 pandemic, the energy crisis, and rising inflationary pressures. These events interacted with pre-existing territorial inequalities, producing persistent and spatially uneven patterns of material and social deprivation. This paper investigates regional disparities in deprivation across Spanish NUTS2 regions over the period 2019–2023 by constructing a multidimensional composite indicator based on the DP2 methodology (Peña, 1977; Somarriba & Peña, 2009). The study pursues three objectives: (i) to operationalize deprivation through a coherent set of harmonized indicators derived from EU-SILC and Eurostat regional statistics; (ii) to compute a DP2-based index that reduces redundancy among correlated indicators through an iterative correction mechanism; and (iii) to identify persistent spatial gradients and crisis-related changes in deprivation levels across regions. The results highlight a stable north–south divide, with southern and insular territories systematically displaying higher deprivation scores and confirm the sensitivity of regional deprivation to external shocks, particularly in regions dependent on vulnerable economic sectors. The findings provide policy-relevant evidence supporting the need for place-based and multidimensional strategies aimed at strengthening territorial cohesion and reducing social vulnerability.

### **1. Introduction**

In recent decades, Spain has often been portrayed as a paradigmatic case of territorial imbalance within the European Union, combining highly competitive regions with territories characterized by persistent structural weaknesses and limited access to opportunities. Despite progress in economic modernization, significant disparities remain between North and South, coastal and inland areas, and metropolitan and rural contexts (European Commission, 2023). Between 2019 and 2023, Spain experienced an exceptional sequence of shocks, including the COVID-19 pandemic, energy crisis, and inflation, which disproportionately affected regions specialized in tourism and low-protection services (Eurostat, 2023). These shocks amplified pre-existing inequalities, particularly in southern and insular territories (Sánchez & Jiménez-Fernández, 2023).

Classical economic indicators, such as regional GDP per capita, only partially represent these dynamics. A region can display high average income while still hosting pockets of severe deprivation related to unemployment, housing insecurity, and limited-service access (Nolan & Whelan, 2011). This has led to a focus on multidimensional deprivation indicators that consider not only income but also factors like housing conditions and energy affordability (Guio, 2009). Composite indicators are increasingly used to synthesize complex phenomena into interpretable metrics for benchmarking and policy evaluation, with careful consideration of methodological choices (Bartram *et al.*, 2024).

This paper uses the DP2 methodology, which reduces redundancy among correlated indicators and allows spatial comparisons of deprivation across regions. By constructing a DP2-based deprivation index for Spanish NUTS2 regions over 2019–2023, the study maps persistent spatial gradients and assesses how crisis-related pressures affected regional deprivation.

The aim of this study is to measure and compare the evolution of material and social deprivation across Spanish NUTS2 regions during 2019–2023. The analysis is guided by three objectives: (i) to define an indicator framework capturing key dimensions of deprivation using harmonized regional data; (ii) to compute a composite deprivation index that accounts for redundancy; and (iii) to identify spatially persistent patterns and temporal shifts associated with economic shocks.

RQ1: Which Spanish NUTS2 regions exhibit higher deprivation levels over 2019–2023?

RQ2: How did deprivation dynamics change during the pandemic and post-pandemic period?

RQ3: Which deprivation-related dimensions contribute most to the composite indicator?

The paper is organized as follows. Section 2 presents the background on territorial deprivation and vulnerability. Section 3 describes data sources and methodology. Section 4 reports results and discusses spatial patterns and temporal dynamics. Section 5 concludes with policy implications.

## **2. Territorial Patterns and Determinants of Material Deprivation in Spain**

Material and social deprivation is increasingly understood as a multidimensional phenomenon that reflects the enforced lack of access to essential goods and services, which individuals or households cannot afford under normal circumstances (Guio, 2009; Nolan & Whelan, 2011). Deprivation can be linked to the inability to achieve a minimum standard of living, where factors such as housing conditions, access to health services, energy affordability, and social participation are crucial. These

dimensions intersect with broader social and economic processes, including labor market segmentation, social exclusion, and regional imbalances, which vary significantly across European territories (European Commission, 2023).

In territorial terms, regional deprivation often manifests in stark spatial patterns, where certain areas—typically peripheral or rural—experience persistent vulnerabilities due to structural weaknesses in economic performance, limited access to public services, and demographic challenges such as aging populations or youth outmigration (Sánchez & Jiménez-Fernández, 2023). This is particularly evident in Spain, where long-standing north-south disparities and differences between urban and rural areas continue to define the landscape of deprivation (Ivaldi & Antonicelli, 2025). Recent economic shocks, such as the COVID-19 pandemic and the subsequent energy and inflation crises, have exacerbated these inequalities, with regions heavily reliant on tourism or low-wage sectors suffering disproportionately from economic disruptions (Eurostat, 2023).

To fully capture these complex and multifaceted phenomena, it is increasingly recognized that traditional economic indicators, such as GDP per capita, fall short in representing the depth of material deprivation. These measures overlook crucial aspects of well-being, such as quality of life, access to essential goods, and housing stability, which are key to understanding social inclusion and cohesion (Nolan & Whelan, 2011). As a result, the use of multidimensional indicators has gained prominence, offering a more comprehensive understanding of regional disparities. These indicators typically combine various dimensions—economic, social, and demographic—into a single composite score, facilitating spatial comparisons and providing valuable insights into regional vulnerabilities (Guio, 2009; Eurostat, 2023).

The construction of composite indicators, however, involves several methodological choices that can significantly affect the interpretability and robustness of results. Key challenges include the selection of relevant indicators, the choice of normalization methods, the determination of indicator weights, and the aggregation approach used to combine different dimensions into a single index (Bartram *et al.*, 2024). A critical decision is the method used to weight the individual indicators. Traditional approaches often rely on arbitrary weighting schemes, whereas newer methods, such as the DP2 methodology, adjust weights based on statistical relationships between variables, reducing redundancy and providing a more accurate representation of regional deprivation (Somarriba & Peña, 2009).

The DP2 approach, developed by Peña (1977), represents a significant advancement in the field of composite indicator construction. Unlike traditional indices, which use ad hoc weighting schemes, DP2 derives weights based on the statistical properties of the data, specifically the variance and co-variance across variables. This ensures that the composite indicator reflects the true

multidimensional nature of deprivation, minimizing the potential for compensatory effects between indicators (Somarriba & Peña, 2009). The DP2 method has been successfully applied in various contexts, including quality of life studies and regional deprivation analyses, offering a transparent and statistically robust alternative to more simplistic aggregation methods (Ivaldi & Antonicelli, 2025).

In the context of Spain, this methodology allows for a more nuanced understanding of territorial disparities by incorporating a wide range of socio-economic indicators and reducing redundancy across correlated variables. The use of DP2 to assess regional deprivation across NUTS2 regions over the period 2019–2023 is expected to provide important insights into how the COVID-19 crisis and other socio-economic shocks have affected material deprivation patterns across the country.

### **3. Data Sources, Simple Indicators and Research Hypotheses**

This study utilizes data from the European Union Statistics on Income and Living Conditions (EU-SILC) and Eurostat regional statistics to construct a comprehensive deprivation indicator for Spanish NUTS2 regions over the period 2019–2023. EU-SILC provides detailed microdata on income, living conditions, and social participation, offering a robust basis for analyzing material deprivation at the household level across different regions of Spain. The dataset includes key variables related to basic living conditions, such as the ability to afford housing, heating, food, and unexpected expenses. These variables are aggregated at the NUTS2 level, ensuring comparability across regions and years.

To capture the multidimensional nature of deprivation, a set of partial indicators is selected from EU-SILC and Eurostat, focusing on key aspects of material and social well-being. These indicators include: (i) the ability to pay rent or utility bills; (ii) the capacity to keep the home adequately warm; (iii) the ability to afford a healthy diet, including meat or protein-equivalent meals; (iv) the capacity to face unexpected financial costs; and (v) access to durable goods such as a washing machine, car, and telephone. These variables are chosen based on their relevance to the concept of material deprivation and their ability to reflect the lived experiences of individuals in different regions (Guio, 2009; Nolan & Whelan, 2011).

In the construction of the composite indicator, the DP2 methodology is employed. The DP2 method is a distance-based approach that constructs a synthetic deprivation index by calculating the distance of each territorial unit from an ideal reference point, which represents the best possible performance across all indicators. Unlike traditional composite indicators, DP2 adjusts for indicator redundancy by calculating the weights for each indicator based on its statistical properties, specifically the

variance and co-variance across the data. This reduces the impact of highly correlated indicators and ensures that the resulting composite score accurately reflects the multidimensional nature of deprivation (Peña, 1977; Somarriba & Peña, 2009).

The reference vector for the DP2 calculation is defined as the best (lowest deprivation) observed performance across all regions and years in the dataset. This approach ensures that the results are comparable across time, as the same reference point is used to compute distances for each year in the study period. The DP2 values are calculated for each region in each year, and the resulting deprivation index provides a clear measure of how far each region is from the optimal deprivation-free state.

Indicator weights are determined endogenously through the DP2 method's iterative procedure. For each indicator, the weight is inversely proportional to its variance and co-variance with other indicators, ensuring that highly redundant variables have a reduced impact on the final index. This method allows for the creation of a non-compensatory indicator, where poor performance in one dimension cannot be offset by better performance in another, thus preserving the integrity of each deprivation dimension (Somarriba & Peña, 2009).

The final composite deprivation index is calculated for each Spanish NUTS2 region for the years 2019 through 2023. The results are then analyzed to identify regional patterns of deprivation, paying particular attention to how deprivation levels have changed over time, especially in response to the economic shocks of the COVID-19 pandemic and subsequent crises. This analysis provides valuable insights into the resilience of regions, the persistence of regional disparities, and the role of specific deprivation dimensions in shaping overall well-being.

#### **4. Methodology**

This study makes use of DP2 method based, originally, on Peña (1977), to consider the multiple aspects and dimensions of material deprivation. The DP2 measure is the distance of each territorial unit to an 'ideal' theoretical point located in a multi-dimensional space where the indicators under consideration would reach their best values. In contrast to more simple aggregation approaches, the DP2 accessory criterion considers the co-dependence of the variables and the level of variation in them, so that the composite indicator explains actual differences without overlap (Somarriba, Peña, 2009; Ivaldi, Antonicelli, 2025).

The DP2 index of a region  $j$  is calculated mathematically as follows:

$$DP2 = \sqrt{\sum_{i=1}^k \left( \frac{X_{ij} - X_i^{ref}}{s_i} \right)^2} * (1 - R_i^2) \quad (1)$$

where:

- $X_{ij}$  = observed value of variable  $i$  in region  $j$ ;
- $X_i^{ref}$  = reference (ideal) value for variable  $i$ ;
- $s_i$  = standard deviation of variable  $i$  across all regions;
- $R_i^2$  = determination coefficient from the linear regression of variable  $i$  on all preceding variables, capturing shared variance and avoiding redundancy.

The  $(1 - R_i^2)$  term serves as a penalty and puts less weight on something highly correlated with something included in the index. It ensures that the composite indicator is not compensatory: low performance in one side cannot be compensated by high performance in another side (Peña, 1977; Somarriba, Peña, 2009). The DP2 approach is especially well suited to the analysis of material deprivation as it is: processes several dimensions at a time, thereby accommodating the multifactorial nature of deprivation; reduces redundancy across the correlated measures for analytic clarity; gives a composite index that allows spatial comparisons both between regions and over time; is insensitive to scale and measurements on variables. Using the DP2 methodology, that interesting map is produced being the first data-based and fine-grained map of material deprivation in Spain, revealing latent patterns that single-variable analyses cannot reach. These are important insights for targeted, evidence-informed regional policies aimed at diminishing disparities and enhancing social inclusion (European Commission, 2023; Ivaldi, Antonicelli, 2025).

## 5. Results

The results of the DP2 analysis for Spanish NUTS2 regions from 2019 to 2023 reveal persistent regional disparities and significant temporal shifts influenced by the socioeconomic shocks of the COVID-19 pandemic and the subsequent energy and inflation crises. The national average DP2 score in 2019 was approximately 0.28, indicating moderate levels of material deprivation across Spain. However, marked regional differences were observed: northern regions, such as Navarre and the Basque Country, exhibited relatively low deprivation scores (around 0.18), while southern and insular regions, including Andalusia, Extremadura, and the Canary Islands, had significantly higher values (over 0.35).

The COVID-19 pandemic had a substantial impact on deprivation levels, particularly in regions highly dependent on tourism and low-wage industries. In 2020, many regions experienced an increase in DP2 scores, with some areas, such as the Canary Islands and Balearic Islands, seeing rises above 0.42. These increases were driven by income losses, housing insecurity, and difficulties in accessing essential services. Although there was some recovery in 2021 and 2022, the DP2 values remained elevated compared to pre-pandemic levels, reflecting the prolonged effects of the crisis. The spatial distribution of material deprivation in Spain is presented in Figures 1 to 5, where regions are color-coded to reflect their DP2 scores. These figures use a gradient scale where darker colors indicate higher levels of deprivation, and the classification is based on quantile categories. For instance, regions in the highest quantile of deprivation are shaded darker, visually emphasizing areas of persistent vulnerability. The DP2 values for each region are listed in Table 1, which presents the exact numerical values for the years 2019–2023. These values in the table correspond to the regional averages and ensure consistency with the figures.

**Table 1** – *Material Deprivation Index (DP2) by Spanish Region, 2019–2023.*

Region (NUTS2)	DP2 2019	DP2 2020	DP2 2021	DP2 2022	DP2 2023
Andalucía	0.36	0.38	0.42	0.40	0.38
Aragón	0.24	0.26	0.28	0.26	0.25
Asturias	0.23	0.24	0.26	0.25	0.23
Balearic Islands	0.33	0.38	0.44	0.40	0.35
Canary Islands	0.38	0.42	0.46	0.43	0.42
Cantabria	0.19	0.20	0.22	0.21	0.19
Castilla y León	0.26	0.27	0.29	0.28	0.26
Castilla-La Mancha	0.28	0.30	0.34	0.31	0.30
Catalonia	0.24	0.26	0.28	0.26	0.24
Valencian Community	0.29	0.32	0.35	0.32	0.30
Extremadura	0.37	0.39	0.43	0.41	0.39
Galicia	0.24	0.25	0.28	0.26	0.24
Madrid	0.23	0.26	0.28	0.26	0.24
Murcia	0.30	0.32	0.36	0.33	0.31
Navarre	0.17	0.18	0.20	0.19	0.17
Basque Country	0.15	0.17	0.18	0.17	0.15
La Rioja	0.19	0.20	0.22	0.20	0.19

Table 1 also includes the DP2 values for Ceuta and Melilla, which were previously omitted in the original version for space reasons but are now included for completeness and clarity.

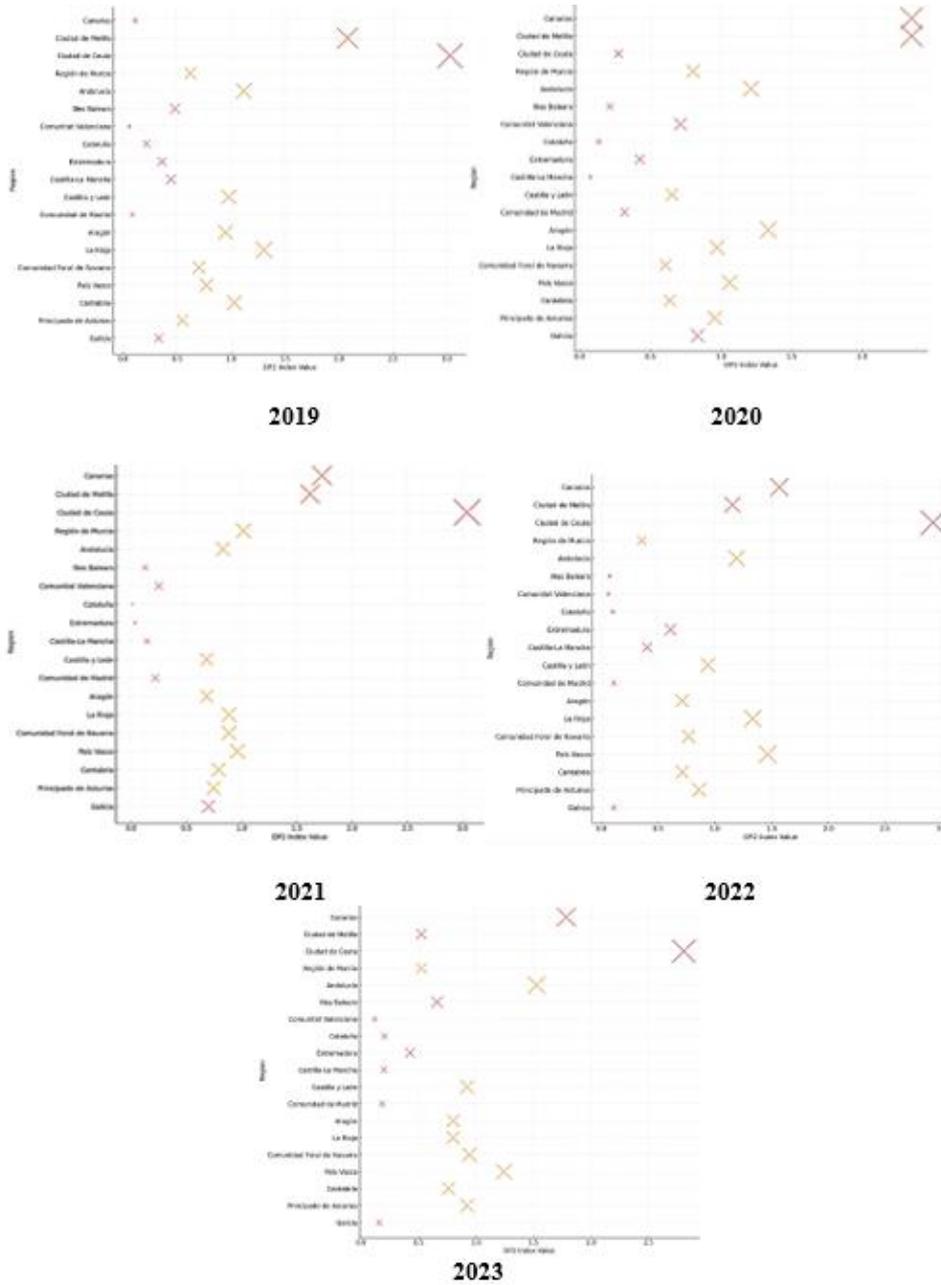
A DP2 score of 0.30 at the national level indicates a moderate level of material deprivation, but the distribution of deprivation was highly uneven across regions. Regions heavily dependent on tourism, such as the Canary Islands and Balearic Islands, saw some of the largest increases in deprivation during this period, with DP2 scores exceeding 0.42 in some areas. The inability to afford unexpected expenses and to keep homes adequately heated were significant challenges during the crisis, highlighting how the economic disruption exacerbated existing vulnerabilities.

By 2021, the effects of the pandemic were still being felt. Although there was some economic recovery, the national DP2 average remained elevated, close to 0.30. Deprivation levels in the most vulnerable regions stabilized but remained well above pre-pandemic levels. Furthermore, urban areas began to show signs of increasing internal polarization. While the overall DP2 scores in regions such as Madrid and Catalonia remained relatively low, certain urban areas experienced rising deprivation, linked to job losses in services and growing housing insecurity.

In 2022, despite some economic recovery, the improvements in material deprivation were modest. The national DP2 index slightly decreased to around 0.28, but this recovery was uneven and insufficient to reverse the damage caused by the pandemic. New sources of stress, particularly the energy price crisis, led to sharp increases in specific deprivation indicators, such as the ability to maintain homes at an adequate temperature. In high deprivation areas, over 25% of households struggled to afford heating, further amplifying regional disparities in deprivation.

By 2023, the national DP2 index decreased to approximately 0.27, indicating a slow recovery toward pre-pandemic conditions. However, the gap between regions remained large. Northern regions saw their deprivation scores improve, with values returning to below 0.18. In contrast, southern and insular regions continued to experience high deprivation, with scores frequently above 0.35. Additionally, intra-urban disparities persisted, suggesting that significant pockets of material deprivation existed even within economically dynamic areas.

**Figure 1 – Spatial Distribution of Material Deprivation in Spain (DP2 Index, 2019, 2020, 2021, 2022, 2023).**



The spatial-temporal analysis reveals several key trends:

- Persistence of structural disparities: Despite some national-level improvements, long-standing regional divides, particularly between northern and southern Spain, remain entrenched.
- Sensitivity to external shocks: The DP2 index captured sharp increases in deprivation during the pandemic, particularly in regions dependent on vulnerable economic sectors such as tourism.
- Multidimensional nature of deprivation: Beyond income, factors like heating adequacy, the ability to manage unexpected expenses, and access to durable goods played a significant role in regional variations in deprivation across all years.
- Urban polarization: Even regions with relatively modest average DP2 scores exhibited deepening internal inequalities, with specific districts showing heightened deprivation.

These findings underscore the importance of adopting a multidimensional approach to regional development policies that goes beyond traditional economic indicators. The DP2 methodology proves crucial in identifying subtle, yet impactful, spatial and temporal shifts in material deprivation, which can inform targeted local interventions aimed at mitigating inequalities and promoting social cohesion in line with EU policy goals.

## 6. Conclusion

The analysis of material deprivation across Spanish NUTS2 regions from 2019 to 2023 reveals significant regional disparities and demonstrates the vulnerability of certain territories to external socioeconomic shocks. While the national average DP2 score indicates a moderate level of deprivation, the regional variation is striking. The northern regions, such as Navarre and the Basque Country, consistently exhibit lower levels of deprivation, while southern and insular regions, including Andalusia and the Canary Islands, experience much higher levels of material hardship. The effects of the COVID-19 pandemic and the energy price crisis exacerbated these disparities, with the most vulnerable regions showing sharp increases in deprivation scores during the crisis.

The results underscore the multidimensional nature of deprivation, where factors such as housing, food security, energy affordability, and access to basic services significantly influence the well-being of regional populations. The DP2 methodology proved to be an effective tool in identifying these complex spatial and temporal shifts in deprivation, capturing both longstanding territorial divides and short-term disruptions caused by the pandemic and subsequent crises. The sensitivity

to external shocks is evident, with some regions experiencing deeper and more lasting deprivation due to their reliance on vulnerable economic sectors, such as tourism and low-wage industries.

The analysis also highlighted the emergence of urban polarization, even in economically developed areas like Madrid and Catalonia. Increasing internal disparities within these regions signal a growing divide between affluent districts and areas suffering from housing insecurity, job losses, and social exclusion. These findings emphasize the need for policies that address not only spatial inequalities but also the internal disparities within urban centers.

The findings have important policy implications for regional development strategies. As the analysis reveals, regional disparities are persistent and multifaceted, requiring multidimensional, place-based interventions. Policies aimed at improving regional cohesion should go beyond traditional economic indicators, incorporating factors related to social exclusion, housing, and access to basic services. The DP2 methodology offers a robust framework for detecting and understanding these disparities, allowing policymakers to design more targeted and evidence-based interventions.

In line with the European Union's Cohesion Policy and the Sustainable Development Goals (SDGs), particularly SDG 1 (No Poverty) and SDG 10 (Reduced Inequality), the results of this study underscore the need for inclusive and context-sensitive policies that foster social cohesion and reduce material deprivation in the most vulnerable regions. Future research could expand the analysis by incorporating additional dimensions of well-being, such as cultural, behavioral, and environmental factors, to further deepen our understanding of territorial disparities and inform more comprehensive policy frameworks.

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