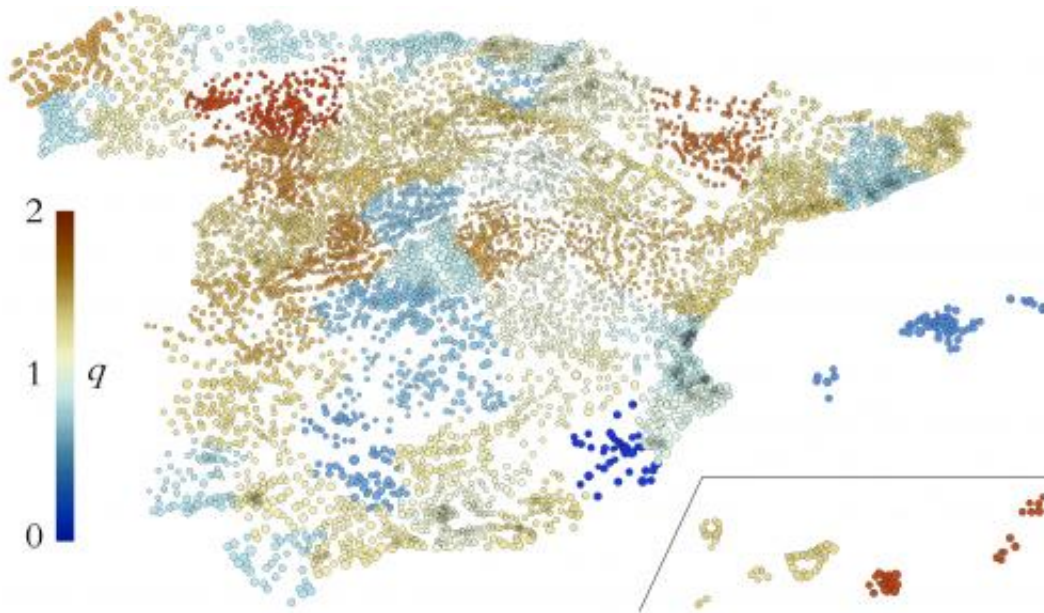


The dynamic of Spain's population follows the maximum entropy principle

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This image shows a map of the population evolution characteristics of Spain's municipalities. Credit: A. Hernando et al.

A team of Spanish and Argentinean researchers have verified that the distribution of the inhabitants in each Spanish province evolves in accordance with the maximum entropy principle in the field of physics. Therefore, this evolution is predictable. The results have allowed authors to put forward a 'socio-thermodynamic' theory that applies the laws of thermodynamics to collective human behaviour.

Spanish and Argentinean scientists have researched the way in which we as people group together on a large scale as a way of seeing whether there is any law or pattern that explains how we behave. Their findings? The maximum entropy principle. At least this is the case in the population distribution of Spain's provinces.

"We have verified that given province characteristics, which we specify as a value named 'q', population distribution over time does not arise by chance but rather by a certain way that adjusts to the maximum entropy principle," as explained to SINC by Alberto Hernando, researcher of the Federal Polytechnic School of Lausanne (Switzerland) and co-author of the study.

Once certain conditions are known, the population evolution of all municipalities in this case, the equilibrium distribution of the system for each one of the provinces is one that maximises the quantity of information or entropy, the latter being the physical [magnitude](#) describing how irreversible the system is.

"In this way, by observing how the population is distributed in each city or town of each province, we have found that on a collective level we obey mathematically predictable patterns," comments Hernando.

To carry out the study published in the *Journal of the Royal Society Interface* they used the [population data](#) provided by Spain's National Statistics Institute (INE) on 8,116 municipalities spread over 50 provinces between 1996 and 2010. There were already more than 47 million people in Spain in 2010.

The 'q' value used by the researchers not only helped them to summarise the socioeconomic characteristics of each province but also to quantify how large population nuclei grow in relation to their smaller counterparts. Their typical value is 1 and reflects that the population

increase of a municipality during the last year studied is proportional to its number of [inhabitants](#) the year before.

Nonetheless, when 'q' is greater than 1 this means that the large municipalities or cities of a province grow at a faster rhythm compared to small municipalities or towns. This is what the data shows in the case of León, for example or Las Palmas de Gran Canaria and Huesca.

This is the general tendency in the majority of provinces, which in turn reflects the progressive abandonment of the countryside in favour of the city. In fact, the average 'q' value within Spain is 1.2.

However, when the 'q' value is less than 1, the interpretation becomes more complex. It could reflect that towns of a province have grown at a greater rate than cities, as in the case of Guipúzcoa, but the particular way in which municipalities with different tendencies group together also plays a role.

According to the data, in Madrid and Barcelona a mixture of the two phenomena is occurring. On the one hand the very small towns are being left whereas on the other hand the city is being saturated. Therefore, the medium sized nuclei are experiencing a relatively higher growth rhythm.

"We are obviously dealing with average figures and it could be the case that a town or city in particular does not fit the rule of its province, but this does not alter statistic properties," says Hernando, who developed this study during his time at the Paul Sabatier University of Toulouse in France.

Along with other colleagues from the University of Granada, the Institute of Interdisciplinary Physics and Complex Systems (CSIC-University of the Balearic Islands) and the National University of La Plata in Argentina have employed these results to formulate a theory

called 'socio-thermodynamics', which is similar to thermodynamics used to describe the equilibrium state of gases, solids and liquids.

The maximum entropy principle is a formulation of the second thermodynamics principle that states that the entropy quantity of the universe tends to increase over time. In other words, a state with a certain order always leans towards a state with less order and the inverse process to this is impossible on a spontaneous level.

According to the researchers, its application to human society can help us to understand how social order always tends to deteriorate if active attempts are not made to avoid such an occurrence. "This without a doubt gives rise to many speculations and interpretations but only one single investigation based on observations and objective data can give us a clear answer," concludes the researcher.

In any case, the authors believe that the predictability provided by this theory could be useful for estimating certain aspects such as migratory flows, future city growth, and the popularity of mass consumer products or even the results of elections.

More information: A. Hernando, R. Hernando, A. Plastino, A. R. Plastino. "The workings of the maximum entropy principle in collective human behavior". *Journal of the Royal Society Interface* 10: 20120758, 2013. [Doi:10.1098/rsif.2012.0758](https://doi.org/10.1098/rsif.2012.0758)

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