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Disparities in Oaxaca's economic development: a regionalization proposal

Disparidades en el desarrollo económico de Oaxaca: una propuesta de regionalización

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Abstract

The state of Oaxaca is one of the states of Mexico with a very low level of economic development, within it its municipalities present strong problems of disparities in their development, these disparities are reflected through variables such as income, education and health. This research makes use of an analytical regionalization method that seeks to contribute to the reduction of disparities between the municipalities of the state through their spatial grouping by optimizing criteria; likewise, to contrast the proposed regionalization, other alternatives such as a cluster-type regionalization and the traditional regionalization that already existing in the state are evaluated through the multicriteria analysis method. The analysis of the results shows that the proposed regionalization contributes to the reduction of disparities in economic development, also with the grouping of the created regions a positive spatial dependence between the municipalities is originated and the disparity between the regions.

Economic development, Regionalization, Spatial analysis

Resumen

El estado de Oaxaca es uno de los estados de México con un nivel de desarrollo económico muy bajo, al interior del mismo sus municipios presentan fuertes problemas de disparidades en su desarrollo, estas disparidades se ven reflejadas a través de variables como lo son el ingreso, la educación y la salud. En esta investigación se hace uso de un método de regionalización analítico que busca contribuir a la reducción de las disparidades entre los municipios del estado a través de su agrupación espacial mediante la optimización de criterios; así mismo, para contrastar la regionalización propuesta, a través del método de análisis multicriterio se evalúan otras alternativas como una regionalización tipo clúster y la regionalización tradicional ya existente en el estado. El análisis de los resultados muestra que la regionalización propuesta contribuye a la disminución de las disparidades en el desarrollo económico, también con la forma de agrupación de las regiones creadas se origina una dependencia espacial positiva entre los municipios y se reducen a su vez la disparidad entre las regiones.

Desarrollo económico, Regionalización, Análisis espacial

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Introduction

The capitalist system as we know it today, has been in constant development and evolution going through several phases such as free competition, imperialism and neocapitalism, within the latter has developed what is now known as globalization; this last stage commonly known as globalization has been the most aggressive of capitalism and the one that has contributed the most to reproduce and increase the disparities in the economic development of regions and countries in the world. Economic disparities are usually the result of production and exchange processes between regions, countries or municipalities and occur when one or some of the members are at a disadvantage (Cuervo & Morales, 2009).

At the global level, the disparities in the economic development of regions and countries can be observed through the Human Development Index (HDI) developed by the United Nations Development Program (UNDP) and which stands as one of the most complete indicators since it is measured through three dimensions that are income, health and education. According to the OECD in a report carried out in 2013 Mexico was classified as a country with a high HDI with a coefficient of 0.739, at the state level there is the Federal District (0.831), Nuevo León (0.790) and Baja California Sur (0.785) with the highest levels of development, at the other extreme are Chiapas (0.647), Oaxaca (0.666) and Guerrero (0.673) with the lowest levels of development (UNDP, Municipal Human Development Index, Mexico, 2013); With respect to the state of Oaxaca, the disparities in development are aggravated and are more evident since in this same report more than 50% of the total of its municipalities present a very low level of development, about 30% have a medium level, 11% register a high level and only 9% have a very high level of development.

In this context of economic crisis (expressed through disparities) that is being experienced, regionalization stands as an interesting alternative to face these problems. Thus, regionalization has been constituted as a mechanism of economic integration with the aim of promoting internal development and inserting itself into the international system (Laredo & Di Prieto, 2001).

In Oaxaca the regionalizations carried out have been carried out from political and cultural criteria, downplaying the importance of the economic factor, there is a lack of scientific work that proposes the creation of new regions with the aim of encouraging the levels of development of the municipalities of the state. With the use of an analytical regionalization method based on the optimization of criteria selected through a rigorous process, it is intended to contribute to the reduction of disparities in the levels of development existing between the municipalities of the state by stimulating a more balanced economic development; in turn, because regionalizations of an analytical nature usually obey specific research or policy objectives, it can contribute efficiently to the generation of a specific strategy to address the problem based on the common characteristics of the municipalities that make up a region, with this type of information you can also create public policies, regional programs or projects to attack the problem based on the strategy developed.

Methodology

For the development of this analysis 4 different but complementary types of methodologies were used, for the establishment of the proposed regionalization a mixed heuristic regionalization method called "regionalization algorithm" was used; Likewise, in order to establish a contrast between the existing regionalization, the proposed regionalization and one of the cluster type, the scenario method is used, which is complemented by the multi-criteria analysis method to be able to evaluate the regionalization alternatives analyzed. Finally, econometric instruments and spatial analysis are used to analyze regionalization as the best alternative to reduce disparities in the economic development of the municipalities of the state of Oaxaca. There are different methods to carry out regionalizations, however from the field of regional science a good method for the statistical analysis of data from a spatial (geographical) perspective requires the aggregation of basic spatial units (areas) into larger units (regions) this in order to preserve greater plausibility, minimize differences in population, reduce the effects of outliers or inaccuracies in the data or simply to facilitate the description and visualization of information through maps (Duque, Ramos, Surinach, & Jordi, 2006).

In this research a regionalization algorithm known as "Max P Regions" is used, this has as its main hypothesis that the design of homogeneous and contiguous regions only makes sense if there are disparities between the areas, this would justify the design of more than one region and would show evidence of spatial dependence which in turn would justify the requirement of spatial contiguity in the formation of new regions.

Because there is currently a type of regionalization widely known and used in the state of Oaxaca, it is important to take into account this element since for many years it has been used as a reference for scientific analysis. It is important not to rule out this regionalization without first having established an analysis through it; to establish parameters and the same conditions before the regionalizations to be analyzed, the scenarios are constructed, which are an instrument that helps to create a context for planning and programming which allows to choose between development options (Yori, Hernández & Chumaceiro, 2011).

For the development of this research, the methodological steps that will be addressed for the construction of the different scenarios are those mentioned by Yori, Hernández, & Chumaceiro (2011) who refer to the methodology developed by Bas, this series of steps is as follows:

1. Decide the system on which to work (variables and relationships).

2. Decide the time space for scenarios (time of occurrence).

3. Deciding how many scenarios you want to build (three or four is ideal).

4. Determine the main variables that will structure the scenarios and discuss assumptions about the future.

5. Define the value that the variables will take in each scenario considered.

6. Decide on specific events that may occur during the temporal space of scenarios.

7. Create a job title for each scenario.

8. Outline the scenarios.

One of the essential and final phases of the scenario method is the evaluation of the same, which will provide the elements that are necessary for decision-making on which scenario is the one that best suits the requirements of this study, as an element to provide an objective evaluation of the different scenarios that will be proposed, in this research, the methodology called Multicriteria Analysis will be used. For this analysis, a specific method called "Importance of Criteria through Intercriteria Correlation" known as CRITIC is used; this is a discrete method since it is based on a limited series of alternative solutions, it is also quantitative since the evaluation or weightings of each criterion is through indicators and the calculation of the specific weights of each criterion is based on the use of statistical tools.

In this method, a decision/weighting matrix is constructed, which according to Muñoz & Romana (2016) must always contain the following elements:

1. Decision criteria: identified by can be defined as the conditions or parameters that allow to discriminate alternatives and establish the preferences of the decision-maker, are reference elements on which the decision is made. $C = (C_1, C_2, \ldots, C_n)$

2. Weights: the so-called weights or weights are measures that allow the decision-maker to determine the relative importance of each criterion. To each criterion a weight must be assigned, this is done by a vector of weights, being the number of criteria; the weights should reflect the importance of the criterion in the decision. For Muñoz & Romana in decision-making there will always be criteria of greater relevance than others, however, this should not translate into those of lesser relevance should not be considered.$[w] = [w_1, \ldots, w_n] n w_i C_i$

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3. Alternatives as alternatives are considered to the different approaches to solve the problem posed, for the problems of discrete multicriteria decision the alternatives will be defined as a finite set of solutions, strategies, actions, decisions etc. possible that have to be analyzed during the process of evaluation and resolution of the problem. Each alternative should clearly show how it solves the problem and how it differs from the other alternatives. The set of alternatives is represented by, where each set of alternatives must be different and mutually exclusive.$A = (A_1, A_2, \dots, A_m) A_i$

Through the weighting matrix, the CRITIC method evaluates through the value of the standard deviation of the normalized criteria and the correlation coefficients which are used to determine a contrast between criteria; this method is then an analytical procedure that allows, through weightings for each criterion, to incorporate the two aforementioned elements, the intensity of the contrast and the conflict, both essential parts contained in the structure of the decision-making of a problem.

Starting from the way in which Aznar and Guijarro (2012) explain this method, we have in a synthesized way that:

$$w_j = S_j \left(\sum 1 - r_{jk}\right) \quad (1)$$

Being:

w_j = weight or weighting of the criterion *j*

S_j = standard deviation of the criterion *j*

r_{jk} = Correlation coefficient between the criteria and jk

In their book Aznar and Pebble, they mention that the weight of a criterion will be greater the higher its standard deviation and the more "different information" of the other criteria it provides (lower correlation coefficient between columns).

To develop a comparison between the different criteria in the CRITIC method, they must first be made comparable to each other, this is done through a process of standardization or normalization of data which has the goodness of transforming the different types and units of measurement to magnitudes between or and 1, thus making them comparable.

The standard deviation for each criterion is estimated based on the following formula:

$$S_j = \sqrt{\frac{\sum_{j=1}^{n} (X_j - \bar{X})^2}{n - 1}}$$

Similarly, the formula for calculating the Pearson correlation coefficient is as follows:

$$r_{jk} = \frac{cov\,(j, k)}{s_j s_k}$$

Because multi-criteria analysis uses the spatial correlation levels of their municipalities to be able to calculate the weighting coefficient and thus choose the best alternative, the regionalization that is selected could observe to some degree spatial dependence; To carry out this analysis, spatial analysis from spatial econometrics (EE) will be used, which mentions that spatial dependence or autocorrelation can be defined as the existence of a functional relationship between what happens at one point in space and what happens elsewhere, which is explained mainly for reasons of human interaction with its physical-environmental environment. From the above, Varonio, Bianco and Rabanal (2012), point out that a spatial autocorrelation implies that the value of a variable is conditioned by the value that that variable assumes in a neighboring region. Moreno and Vayá (2004) show the most common statistics in the analysis of spatial dependence at the global and local level, these statistics allow to contrast the presence or absence of a spatial dependence scheme; that is, to contrast whether the hypothesis that a variable is distributed completely randomly in space is fulfilled or if, on the contrary, there is a significant association of similar or dissimilar values between neighboring regions Statistics at the local level arise because a global dependency test may not detect dependence in all units of the analyzed space.

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The most commonly used global and local statisticians are usually the Moran statistic and the New-Gi tests.

Finally, it is necessary to predict the behavior that economic development (HDI) can take in each of the regions of the alternative that was the most appropriate, for this a time series analysis is performed, which time is one of the most important tools in econometrics, the value and importance given to this type of analysis lies in its ability to make forecasts and in the power and accuracy that these possess. The predictive capacity of a time series is directly related to the seasonality of it, this concept refers to a stochastic or random process which is a collection of random and ordered variables in time (Gujarati, 2010), The projection or forecast is made through an integrated autoregressive of moving averages known as ARIMA.

Results

Exploratory scenarios are those that start from the analysis of past and present trends and that in turn will try to lead us to a probable and desirable future (Gastó, 2005); the two scenarios that are created in this research to contrast with the existing one, are precisely of the exploratory type and will seek to improve the existing conditions between the variables analyzed.

The two scenarios built on the basis of analytical methods seek to contribute to the system on which we are going to work and this system is based on trying to reduce disparities in the economic development of the municipalities through a new integration of them; however, Max P regionalization is the one that focuses most on achieving this objective since it focuses on reducing the heterogeneities of the variables or elements it seeks to optimize.

Addressing in a flexible way the methodological steps for the construction of scenarios of the methodology developed by Bas, these are structured as follows:

1. System: the system on which these scenarios will work is the one mentioned in the previous paragraph, in this one it is sought to reduce the disparities in economic development through the formation of new regions based on an analytical method.

2. Temporality: the temporal space on which the scenarios develop is determined by the temporality of the variables used for their creation; at first it is considered that its term of occurrence is from the year 2015 onwards, this due to the availability of data.

3. Number of scenarios: the number of scenarios built is 2, however, the analysis incorporates the already existing state regionalization.

4. Main variables: the Human Development Index (HDI), the Municipal Functional Capacities Index (ICFM), the Total Gross Production per employed personnel (PBTpo) and the Value Added on average per employed personnel (VAPpo) are considered for the construction of the scenarios.

5. Value of the variables: in the construction of these scenarios the value that the variables must take will not be determined by those that were used for their choice, to meet this point a multicriteria analysis is carried out.

6. Title of the scenarios: Traditional regionalization, Max P Regionalization and Cluster Regionalization.

7. Outline of the scenarios: the design of the scenarios will be geographical, showing in each of them the regions in which it will be divided and the member municipalities.

Variable selection

In this research, the variables chosen for the construction of the regions were social, political/governmental and economic, precisely due to the existence of data through different indicators and their existence at different points in time. this analysis will begin by showing and explaining each of the selected indicators, as well as their relevance and quality.

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As a social variable, the Human Development Index (HDI) was selected, this indicator according to the Municipal Human Development Report 2015 called "Transforming Mexico from the local", tries to measure well-being based on the dimensions of health, education and income. Health is about measuring the joy of both a long and healthy life, education quantifies access and income is obtained resources for a dignified life.

To consider the performance of each municipal government in the construction of the scenarios, for the political/governmental variable, the Municipal Functional Capacities Index (ICFM) was taken, calculated for the first time in 2016 and created as well as the HDI by the United Nations Development Program (UNDP); there is a strong relationship between the development of a municipality and the capacities that its governments have to meet the needs of its population, this indicator measures precisely those capacities in administrative terms which are developed through involving relevant actors, diagnosing, formulating policies and strategies, budgeting, managing and evaluating.

With respect to the variables of an economic nature, two were the selected indicators, these are incorporated from the perspective of giving weight to economic activity, as a criterion for shaping the regions, but at the same time relate this activity with the employment levels of the municipalities; to achieve this, the selected indicators were the following: Total gross production per total employed personnel and Value added on average per person employed

Multi-criteria analysis

As already mentioned above, once the scenarios are structured, it is time for them to enter a phase of evaluation of them to be able through an objective and rigorous analysis to decide which of the three alternatives is the best. The multicriteria analysis is the tool used to make the decision of the best possible alternative, this will be carried out through an adaptation made for this research of the method of Importance of the Criteria through the Correlation of Intercriteria (CRITIC).

The CRITIC method seeks to evaluate the alternatives, in order to help in the decision-making process, through the analysis of the value of the standard deviation of the criteria and their correlation coefficients. In the CRITIC methodology, the standard deviation is used as a measure of the amount of information of each criterion, therefore, the greater this, the greater the amount of information each of them will provide; however, for this analysis the standard deviation of the criteria is approached differently, since this is a measure that quantifies the dispersion of the data, in this case a greater dispersion would mean greater disparity between the HDI samples for each region analyzed, what is then sought is a low standard deviation for each established criterion.

As for the correlation coefficients of the criteria, which seek to analyze if several criteria are correlated with each other and thus unify them, therefore, the ideal would be to find low correlation coefficients; For this analysis on the contrary, since the spatial correlation coefficients will be used, it is expected that the coefficients will be high since this would mean that by increasing the economic development of a municipality, it will also tend to increase the development of neighboring municipalities correlated to it.

The last important element of the CRITIC method is the calculation through the standard deviation and correlations of a coefficient of weights or weighting of the criteria, this coefficient is used to evaluate the different alternatives and select the one that best suits the objective pursued. In the traditional method it is expected that the coefficient of weights associated with the criteria is high, which would translate into high standard deviations with low correlation coefficients, what is sought then is to select that alternative with the highest weighting coefficients; however, for this adaptation the opposite is sought, a coefficient of associated weights would reflect a low standard deviation (dispersion of the HDI) and high coefficients of spatial correlation between the municipalities, therefore the best alternative will be the one that results with the lowest value of this coefficient.

The decision-making process begins with the analysis of the standard deviation of the regions (criteria) that make up each regionalization (alternatives), in Table 1 you can see the results obtained.

Alternatives	Standard deviation matrix									
	Associated criteria (regions)									
		Region 1	Region 2	Region 3	Region 4	Region 5	Region 6	Region 7	Region 8	Average S
	Traditional Regionalization	0.0537	0.055	0.1915	0.075	0.0649	0.0516	0.0412	0.0912	0.0780
	Max P Regionalization	0.0571	0.0472	0.067	0.126	0.0512	0.0981	0.0712	0.0541	0.0715
	Cluster Regionalization	0.0768	0.0915	0.0509	0.0533	0.0606	0.1772	N/A	N/A	0.0851

Table 1 Standard deviation matrix of criteria
Source: Own elaboration

In the above matrix it is observed that the lowest HDI standard deviation belongs to region 7 of traditional regionalization with a coefficient of 0.0412, while the highest coefficient is from region 3 with a value of 0.1915 also belonging to this type of regionalization; the most favorable coefficient of Max P regionalization was that of its region 2 with a value of 0.0472 and the highest standard deviation was presented by region 4 with a value of 0.126; finally, for cluster regionalization the lowest value was 0.0509 and the highest was 0.1772, representing its regions 3 and 6 respectively.

Since these coefficients in isolation do not generate enough information to know which of the alternatives presents the least dispersion with respect to the HDI of their respective regions that integrate them, the average coefficient of standard deviation has to be analyzed, in this sense it is shown that the coefficient obtained by the Regionalization Max P rises with the best result since it yields a value of 0.0715, while traditional regionalization obtains the second best result with 0.0780 and the last cluster regionalization with 0.0851. The result obtained here shows that the second alternative is one in which the grouping of their municipalities in the established regions provides a better integration which contributes to the reduction of the dispersion of the HDI data analyzed.

Now, since the simple analysis of the dispersion of the data is not enough, the spatial correlations obtained for each region of the proposed three-year periods will be analyzed (Table 2), as already mentioned before, the expected result is high correlation coefficients since this would reflect that the HDI levels of the analyzed regions would increase as that of the municipalities with whom they have a geographical contiguity increases.

Alternatives	Matrix of spatial correlations									
	Associated criteria (regions)									
		Region 1	Region 2	Region 3	Region 4	Region 5	Region 6	Region 7	Region 8	Average Rs
	Traditional Regionalization	0.405	0.28	0.293	0.147	0.475	0.394	0.231	0.604	0.354
	Max P Regionalization	0.432	0.294	0.44	0.768	0.17	0.141	0.404	0.194	0.355
	Cluster Regionalization	0.133	0.648	0.327	0.389	0.494	0.287	N/A	N/A	0.379

Table 2 Matrix of spatial correlations of the criteria
Source: Own elaboration using the GeoDa software for the calculation of the coefficients

Starting with the alternative of the traditional regionalization of the state of Oaxaca, in the matrix of spatial correlations it can be observed that the highest coefficient is from its region 8 while the lowest is that of region 4, with values of 0.604 and 0.147 for each of them; in regionalization Max P the highest value is .768 in region 4 and the lowest is 0.17 in region 5; with respect to cluster-type regionalization this has region 2 with the highest coefficient of the entire matrix, which takes a value of 0.648, its lowest value belongs to region 1 with a standard deviation of 0.133.

As in the previous matrix, the result that is relevant to decision making is the average value of each of the alternatives. While traditional regionalization and Max P take very similar average values in their spatial correlations, with 0.354 and 0.355 respectively; it can be observed that the cluster region was the one that showed the best average value, with a spatial correlation coefficient of 0.379; however, the differences between the results of the alternatives are minimal, so it can be inferred here that the final impact of any of these regionalizations with respect to the spatial correlation of the HDI of the municipalities will be almost the same.

Finally, in order to be able to lean on the choice of any of the three alternatives analyzed here, the solution that provides the best balance between the expected result of the standard deviation and the spatial correlation of the HDI will have to be sought. The weighting coefficient or associated weights is the calculation used to measure and evaluate the performance of the regionalizations and based on this choose the one that gives us the best result; the expected result here is a low coefficient of associated weights since this would express the balance between a low disparity of the HDI data and a high correlation of the municipalities of each region analyzed with respect to the same variable. The following table (3) shows the results of calculating the weights of each criterion for each of the alternatives.

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Alternatives	Matrix of associated weights									
	Associated criteria (regions)									
		Region 1	Region 2	Region 3	Region 4	Region 5	Region 6	Region 7	Region 8	Average W
	Traditional Regionalization	0.0320	0.0396	0.1354	0.0640	0.0341	0.0313	0.0317	0.0361	0.0505
	Max P Regionalization	0.0324	0.0333	0.0375	0.0292	0.0425	0.0843	0.0424	0.0436	0.0432
	Cluster Regionalization	0.0666	0.0322	0.0343	0.0326	0.0307	0.1263	N/A	N/A	0.0538

Table 3 Matrix of weights associated with the criteria
Source: Own elaboration using the GeoDa software for the calculation of the coefficients.

For traditional regionalization the associated weight of lower value is associated with region 7 and is 0.317, in this alternative it can be observed that regions 1, 2, 5, 6, 7 and 8 have very similar and favorable results, however, region 3 has an associated weight too high (0.1354) with respect to its other member regions.

In the Max P alternative, all regions have low associated weights, with region 4 being the best performing with a weight of 0.0292, while region 6 was the one that obtained the highest value with a weighting of 0.0843. Finally, in the cluster-type regionalization all its regions obtained a good performance in terms of the values of their associated weights, however, region 6 contrasted with this performance trend and showed a high value of 0.1263.

Since the choice of the best alternative (regionalization) is determined by the one that on average shows the best result with respect to the weight associated with its criteria (regions) in the matrix, it is observed that the best performance is obtained by Max P regionalization with an associated weighting average of 0.0432; this indicates that there is for this alternative a better relationship between low standard deviation levels and high levels of spatial correlation of their municipalities with respect to the Human Development Index. As a second alternative with a coefficient of associated weights of 0.505 is traditional regionalization, and finally, with a value of 0.0538 is cluster-type regionalization.

Spatial analysis of Max P regionalization

the multi-criteria analysis developed in the previous section determined that the best alternative to reduce disparities in the economic development of the municipalities of the state is the Regionalization Max P, is also in turn guarantees the existence of certain positive levels of spatial correlation of their municipalities, which would cause them to contribute to each other when they increase their levels of development; however, the existence of these levels of spatial correlation does not guarantee that all the member municipalities of a region are correlated, to determine which of them are those that are developed in this analysis. To clarify a little, it is understood by spatial correlation coefficient to the positive or negative relationships that two or more places in a space have with respect to their neighbors, this indicator can be calculated globally or locally through the Moran coefficient which oscillates between values ranging from -1 to 1.

In Figure 1 you can see the global spatial correlation coefficient of the HDI in the state of Oaxaca, this presents a value of 0.398, this result indicates a correlation to consider within the municipalities of the state, since when the neighbors with whom a municipality maintains a geographical contiguity increase their HDI values by one unit, it will do so in the value presented here.

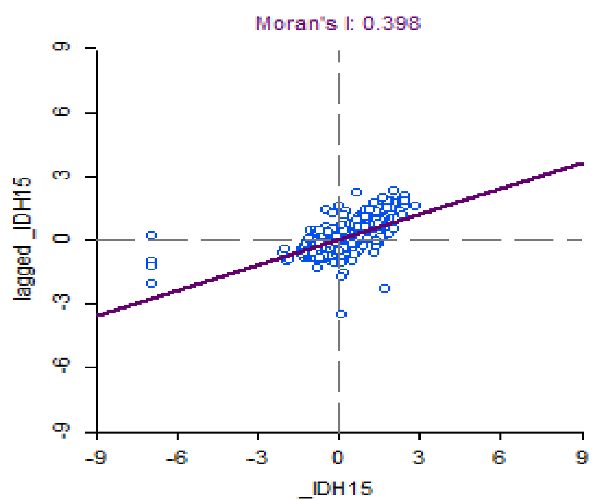

Figure 1 Moran's overall statistic
Source: Own elaboration using the GeoDa software

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HDI projection by region

To analyze the HDI trend in each of the proposed "Max P" regionalization regions, an integrated autoregressive model of moving averages (ARIMA) from the econometric analysis of time series mentioned above was used, with the aim of predicting the values that it may acquire in the future.

HDI values were calculated based on the year 2000 to 2035, for each of the 8 proposed "Max P" regions. It should be mentioned that the last official calculation for the Human Development Index by the United Nations Development Program (UNDP), was made in 2015 so from 2016 the data obey the predictions made.

Figure 2 shows the trend that each of the regions acquires, in this one you can initially observe two very marked cyclical periods; both of them composed of a period of growth, one of degrowth and later accompanied by one of moderate recovery; this effect is observed at the state level and since it is the state that directly influences the development of each of the municipalities, it is replicated in turn in each of the regions analyzed. The first period, which runs from 2000 to 2015, is composed of official data calculated by UNDP, while the second period from 2015 to 2035 is composed of data projected using the ARIMA model.

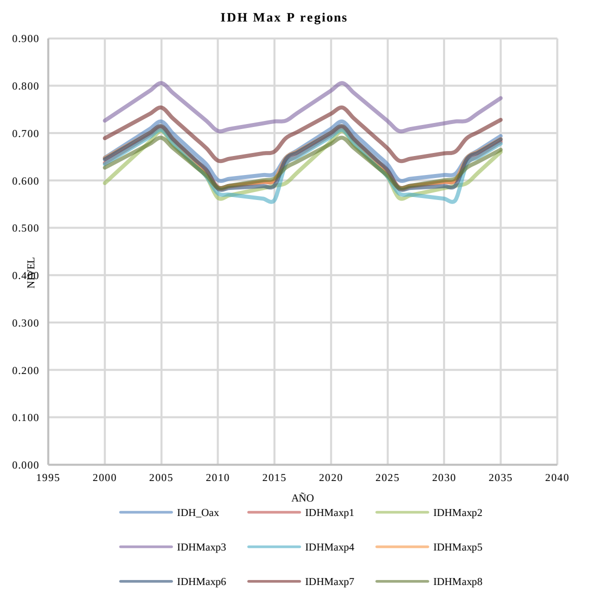

Figure 2 HDI Projection by Region
Source: Own elaboration based on data calculated with the R software.

Table 4 (annexes) shows the Human Development Index data for the state of Oaxaca and the proposed regions; For the year 2000 the state presented an HDI level of 0.648 so that 5 years later in 2005 it observed a growth of 0.077 units and thus be placed with an index of 0.725, later the HDI falls very markedly, in 2010 its performance was 0.601 and recovering slightly for the year 2015 with an index of 0.614; through this data you can analyze the cyclical period mentioned above and that was shown visually in the previous graph. The state observed a first period of satisfactory growth and then suffered a fall and then a slight recovery, an effect observed in all regions.

In the second cyclical period that includes from 2015 to 2035, the trend mentioned in the previous paragraph is repeated, from 2015 to 2020, the state observes a growth of 0.095 units going from an HDI level of 0.614 to 0.709; subsequently, the prediction made marks a fall in the levels of the HDI in the following 10 years, the state decreases by 0.097 units and would be placed at a level of 0.612 with respect to its HDI. In the last 5 years of the prediction made is accompanied by a period of growth, which would indicate the beginning of the cyclical process that we have mentioned and analyzed above; in this period of 5 years the state would obtain an HDI level of 0.694, a level that would not reach the best performance of the state that was observed in 2005 but that would still represent a high level of HDI.

With respect to the regions, the behavior observed by the HDI at the state level reproduces something that is to be expected because it is the state that determines through its public, fiscal, economic policies, etc. the direction that development will take; there are two regions that with respect to their HDI levels stand out above the others, these are the Max P3 region and the Max P7, this is due to the municipalities that make them up, since they become some of the municipalities with the best economic performance in the state.

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With respect to the Max P3 region, some of the most important municipalities that make it up are Oaxaca de Juárez, Ocotlán de Morelos, San Antonio de la Cal, San Jacinto Amilpas, Santa Cruz Xoxocotlán, Santa Lucía del Camino, Etc. For its part, the Max P7 region has municipalities such as Ciudad Ixtepec, Salina Cruz, Santa María Huatulco, San Pedro Pochutla, Santo Domingo Tehuantepec, among others.

Taking as a reference point the year 2005 which is the year in which the Max P regions observed their best levels of economic development and contrasting with the last one for which the forecast was made, it is observed that although all regions suffer they observed a fall in their HDI levels, the recovery in 2035 is very close to the best observed HDI record; for this last year the Max P1 to 8 regions observed a level of development of 0.694, 0.682, 0.661, 0.774, 0.678, 0.688, 0.687, 0.728 and 0.665, respectively.

Something that is important to note is that despite the cyclical process presented by the HDI levels of the state of Oaxaca and the proposed regions, the way in which these regions are grouped together creates a reduction effect of regional disparities, both in the graph exposed and in the data shown, it is observed that, with the exception of the Max P3 region, all the others follow very similar or close levels of economic development, thus contributing to reduce the disparity gaps between regions with the type of municipal grouping proposed, this trend is reproduced throughout the entire period analyzed, from the year 2000 to 2035.

Annexes

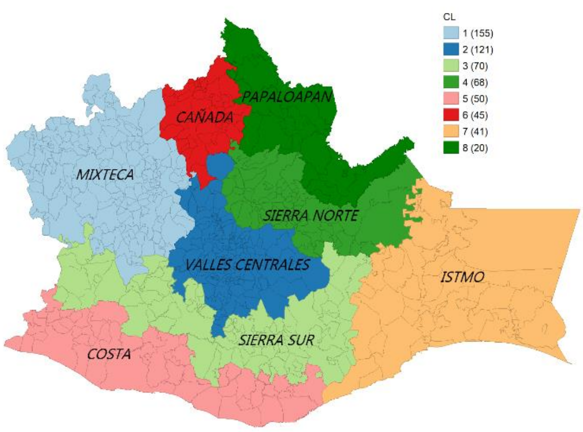

Figure 3 Regional and municipal division of the state of Oaxaca
Source: Own elaboration using the GeoDa software

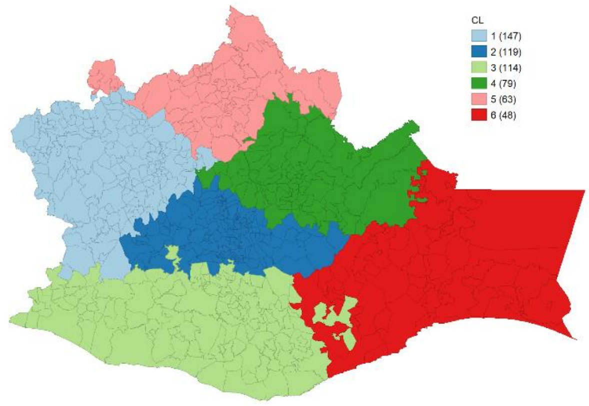

Figure 4 Regional and municipal division by the Max P Regions method
Source: Own elaboration using the GeoDa software

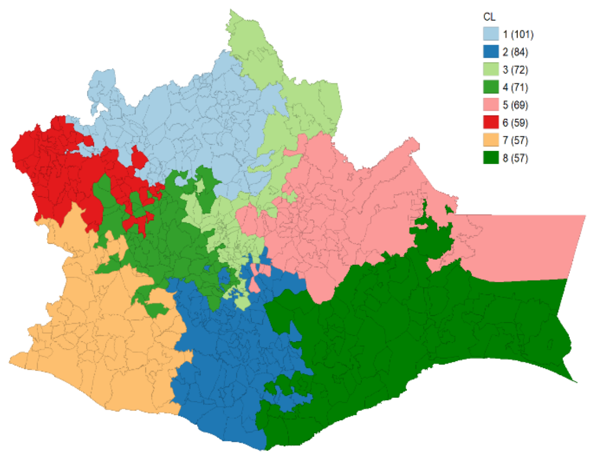

Figure 5 Regional and municipal division by cluster method
Source: Own elaboration using the GeoDa software

Date	IDH Oax	IDH Maxp 1	IDH Maxp 2	IDH Maxp 3	IDH Maxp 4	IDH Maxp 5	IDH Maxp 6	IDH Maxp 7	IDH Maxp 8
2000	0.648	0.637	0.595	0.726	0.635	0.647	0.645	0.689	0.627
2001	0.663	0.652	0.617	0.742	0.649	0.661	0.659	0.702	0.640
2002	0.679	0.667	0.639	0.758	0.664	0.674	0.673	0.715	0.652
2003	0.694	0.682	0.661	0.774	0.678	0.688	0.687	0.728	0.665
2004	0.709	0.697	0.683	0.790	0.693	0.701	0.701	0.741	0.678
2005	0.725	0.712	0.705	0.806	0.707	0.715	0.715	0.754	0.690
2006	0.700	0.687	0.676	0.786	0.680	0.688	0.688	0.732	0.669
2007	0.678	0.665	0.653	0.766	0.656	0.665	0.666	0.710	0.650
2008	0.656	0.643	0.631	0.746	0.632	0.642	0.644	0.689	0.630
2009	0.634	0.620	0.608	0.726	0.608	0.618	0.622	0.668	0.610
2010	0.601	0.586	0.564	0.705	0.573	0.584	0.583	0.642	0.585
2011	0.604	0.589	0.569	0.709	0.570	0.587	0.584	0.646	0.589
2012	0.606	0.592	0.574	0.713	0.567	0.591	0.586	0.650	0.593
2013	0.609	0.594	0.579	0.717	0.565	0.594	0.587	0.654	0.597
2014	0.612	0.597	0.584	0.721	0.562	0.598	0.588	0.658	0.601
2015	0.614	0.600	0.589	0.725	0.559	0.601	0.590	0.661	0.604
2016	0.648	0.637	0.595	0.726	0.635	0.647	0.645	0.689	0.627
2017	0.663	0.652	0.617	0.742	0.649	0.661	0.659	0.702	0.640
2018	0.679	0.667	0.639	0.758	0.664	0.674	0.673	0.715	0.652
2019	0.694	0.682	0.661	0.774	0.678	0.688	0.687	0.728	0.665
2020	0.709	0.697	0.683	0.790	0.693	0.701	0.701	0.741	0.678
2021	0.725	0.712	0.705	0.806	0.707	0.715	0.715	0.754	0.690
2022	0.700	0.687	0.676	0.786	0.680	0.688	0.688	0.732	0.669
2023	0.678	0.665	0.653	0.766	0.656	0.665	0.666	0.710	0.650
2024	0.656	0.643	0.631	0.746	0.632	0.642	0.644	0.689	0.630
2025	0.634	0.620	0.608	0.726	0.608	0.618	0.622	0.668	0.610
2026	0.601	0.586	0.564	0.705	0.573	0.584	0.583	0.642	0.585
2027	0.604	0.589	0.569	0.709	0.570	0.587	0.584	0.646	0.589
2028	0.606	0.592	0.574	0.713	0.567	0.591	0.586	0.650	0.593
2029	0.609	0.594	0.579	0.717	0.565	0.594	0.587	0.654	0.597
2030	0.612	0.597	0.584	0.721	0.562	0.598	0.588	0.658	0.601
2031	0.614	0.600	0.589	0.725	0.559	0.601	0.590	0.661	0.604
2032	0.648	0.637	0.595	0.726	0.635	0.647	0.645	0.689	0.627
2033	0.663	0.652	0.617	0.742	0.649	0.661	0.659	0.702	0.640
2034	0.679	0.667	0.639	0.758	0.664	0.674	0.673	0.715	0.652
2035	0.694	0.682	0.661	0.774	0.678	0.688	0.687	0.728	0.665

Table 4 HDI regressions by region
Source: Own elaboration based on data calculated with the R software

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Conclusions

In the multi-criteria analysis developed, a contrast is made between three regionalization proposals called scenarios, scenario 1 represents the traditional regionalization of the state, while scenarios 2 and 3 obeyed the Regionalization Max P and the Cluster type, in that order; these analytical scenarios were previously constructed following a methodological development and establishing the variables or criteria that were sought to optimize in these models of grouping of geographical or spatial units.

By means of an adaptation of the traditional CRITIC method, the standard deviations and spatial correlation coefficients of the Human Development Index were analyzed in each region of the proposed scenarios; in this adaptation of the aforementioned method, a low standard deviation is sought since it would indicate a lower dispersion in the HDI samples in each region and high spatial correlation coefficients, which would show the spatial dependence of the municipalities in each region; by means of this calculate a weighting that allows to evaluate the best option.

With respect to the results of the standard deviation, the Regionalization Max P is the one that showed a better result with a coefficient of 0.0715, in second place, the traditional regionalization was located with 0.0780 and the last the cluster tip with 0.0851; this result shows that the disparities with respect to the HDI coefficients for each of its proposed regions are smaller, so this type of grouping contributes to reduce the disparity in economic development both between the proposed regions and between their municipalities, this by the fact that it was taken as an optimization criterion to reduce the disparities observed in the HDI.

In the spatial correlation matrix carried out, the average spatial correlation coefficient of traditional regionalization and Max P regionalization are quite similar, the second obtaining a very slight advantage with a coefficient of 0.355 by one of 0.354, in both the HDI would increase on average by .35 in the hypothetical case that the development of neighboring municipalities increased by one unit; the best result seen here is that of cluster-type regionalization with a coefficient of 0.379, which may be due to its smaller number of regions and in turn the greater compactness of them, which is a key element in this type of regions.

To decide which region shows the best conditions in terms of lower levels of HDI disparity and better spatial correlation effects, the coefficient of weights associated with the regions was calculated. The associated weight coefficient sought the best relationship between low levels of disparity in economic development and a high spatial correlation in each region of the scenarios analyzed; a low coefficient indicates low dispersion and high correlation novices; the opposite happens for high levels of the coefficient.

To select the best regionalization alternative among the three analyzed, the average associated weighting coefficient was estimated, with Max P regionalization showing the best performance with a value of 0.432, followed by traditional regionalization with a higher value of 0.505 and finally cluster-type regionalization which obtained the worst performance with a result of 0.538.

The result obtained by the associated weighting coefficient of the Max P regionalization guarantees that it is in it that by grouping the municipalities through their 8 proposed regions, the levels of disparity in economic development are reduced and in turn maintains an acceptable level of spatial correlation between their municipalities; in this way it can be observed that through this adaptation of the CRITIC method it is possible to corroborate the proposed hypothesis in which it is affirmed that through the creation of new regions it contributes to reduce disparities and stimulate a more balanced development, this is achieved through the use of an analytical model where the optimization of the selected criteria (selected variables of the model) is prioritized. for the creation of the proposed regionalization.

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In the spatial analysis of Max P regionalization, the levels of spatial dependence existing at the regional level are investigated in greater depth through the spatial correlation matrix already analyzed. At the global level, the spatial correlation coefficient was very close to 0.40, a value of great relevance since it reveals an important dependence among the municipalities of the state with respect to economic development. At the local level, the regions that observed the highest correlation levels are Max P4 with the best performance and a coefficient of 0.768, followed by the Max P region 3, 1 and 7 with values of 0.440, 0.432 and 0.404; exceeding all of them the overall coefficient of dependence.

The lowest levels of spatial correlation were presented in three regions, Max P5, 6 and 8 with respective coefficients of 0.170, 0.171 and 0.194; it is important to note the fact that 50% of Max P regions were above .40 as this indicates that this type of regionalization not only contributes to reducing disparities in economic development internally; but in turn, in most of its regions, the coefficients show that the municipalities present good levels of spatial correlation, that is, through the proposed groupings, the HDI level of a municipality will be raised when the HDI level is raised in the municipalities with which they have a geographical contiguity.

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