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**Conference Paper**

## Analysis of the Concentration of the Structural Funds in the Autonomous Communities in Spain

39th Congress of the European Regional Science Association: "Regional Cohesion and Competitiveness in 21st Century Europe", August 23 - 27, 1999, Dublin, Ireland

**Provided in Cooperation with:**

European Regional Science Association (ERSA)

*Suggested Citation:* Llinas, Joan Baro; Cabases Pique, Ma Angels; Gomez Adillon, Ma Jesus (1999) : Analysis of the Concentration of the Structural Funds in the Autonomous Communities in Spain, 39th Congress of the European Regional Science Association: "Regional Cohesion and Competitiveness in 21st Century Europe", August 23 - 27, 1999, Dublin, Ireland, European Regional Science Association (ERSA), Louvain-la-Neuve

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**ERSA 39<sup>th</sup> EUROPEAN CONGRESS 1999**

**THE TITLE OF THE PAPER:** ANALYSIS OF THE CONCENTRATION OF THE STRUCTURAL FUNDS IN THE AUTONOMOUS COMMUNITIES IN SPAIN

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**THE THEME TO WHICH PAPER RELATES:** THEORY AND METHODOLOGY OF REGIONAL SCIENCE

# **ANALYSIS OF THE CONCENTRATION OF STRUCTURAL FUNDS IN THE AUTONOMOUS COMMUNITIES IN SPAIN**

## **ABSTRACT**

In this paper we analyse the distribution in Spain, of the European Regional Development Fund community structural help, considering its importance in volume. This survey is carried out in each autonomous community and in two five-year periods, being the first period 1989-1992 and the second one 1994-1999.

First of all we work out measures of concentration in order to point out the difference in the concentration of the ERDF per capita, assigned by the European Union to the Autonomous Communities in the two periods which are analysed.

The indicators propose are measures derive from the concentration graph, so that we can observe the existence of greater or minor concentration depending on the degree of convexity of the graph line, and obtaining distances of interest between the straight line of equidistribution and the graph line which reflect the inequality in the distribution of the ERDF per capita.

Secondly, a typological analysis of the Autonomous Communities is carried out, for the two periods, taking into account the economic variables which affect the distribution of the European Regional Fund and with the purpose of describing repercussions of the implementation of the MAC.

## INTRODUCTION

Since its incorporation into the EEC in 1986, Spain has benefited from European Community Structural Fund aid. The Treaty of Rome, which constituted the EEC and was signed in 1958, referred directly to the reduction of inequalities between the member states, but only did so in a general way. During 1958 the ESF (European Social Fund) was created and in 1962 the EAGGF- Guidance Section (European Agricultural Guidance and Guarantee Fund) was created, and these intervened in European community regional policy, in a modest and implicit way. It was not until seventeen years later, in 1975 that with the creation of the ERDF (European Regional Development Fund) a boost was given to the Community's regional policies.

The incorporation of the Spain and Portugal (1986), considerably increased the discrepancies in income between the different regions of the European Community. Shortly after this the Treaty underwent a major modification with the adoption of the Single European Act (1987). The principle of Cohesion was established, reflected in Article 130 of the new Treaty, which reinforces the European Community regional policy and its instruments of implementation.

Article 130 announced the reform of the Structural Funds (ERDF, ESF and EAGGF-G) which implied a new design of these funds and the doubling of their economic value.

The objectives of this reform of the structural funds are identified with problems, which in a general way affect an entire region or administrative territory within the European Union. The areas eligible for structural funds are indicated, with five different objectives:

Objective 1: To promote the development and adaptation of less advanced regions.

Objective 2: To reconvert those regions gravely affected by the industrial crisis.

Objective 3: To fight against long-term unemployment.

Objective 4: To facilitate professional occupation of young people.

Objective 5: Contains two objectives:

Objective 5a: To adapt the structures of production, transformation and commercialisation in agriculture and forestry.

Objective 5b: To promote the development of rural areas.

In 1989, a new stage began, as the reform of the structural funds entered into force and the European Community regional policy now had at its disposal instruments to redress imbalances between the different regions of the European Union. The same year saw the birth of the CSFs (Community Support Frameworks) applying to periods of several years, and these were to designed coordinate actions and available resources. In 1993 the CSF for 1989-1993 ended and the 1994-1999 was negotiated.

In Spain, out of the total volume of aid proceeding from structural funds, the ERDF (with Objectives 1, 2 and 5b) contributes more than 50% of the total aid. If we study the aid by objectives, it is concentrated in areas eligible for Objective 1, an important part of the funds being received for this objective (aid for less advanced regions).

This study analyses the distribution, in Spain, of the community structural aid from the ERDF, given its importance in terms of volume, by autonomous region and during two five year periods, the first running from 1989 and 1993, and the second period between 1994 and 1999.

TABLE 1: PERIOD 89-93

| AUTONOMOUS REGIONS | OBJECTIVE 1 (MECU) | OBJECTIVE 2 (MECU) | OBJECTIVE 5b (MECU) | ERDF (MECU) | ERDF PER CAPITA (ECU per capita) |
|--------------------|--------------------|--------------------|---------------------|-------------|----------------------------------|
| ANDALUSIA          | 1729               |                    |                     | 1729        | 249,1                            |
| ARAGÓ              |                    | 74                 | 25                  | 99          | 91,0                             |
| ASTURIES           | 351                |                    |                     | 351         | 320,9                            |
| BALEARS            |                    |                    | 7                   | 7           | 22,6                             |
| CANÀRIAS           | 560                |                    |                     | 560         | 374,9                            |
| CANTABRIA          |                    | 55                 | 4                   | 59          | 111,9                            |
| CAS.-LA MANXA      | 779                |                    |                     | 779         | 469,7                            |
| CASTILLA-LLEÓ      | 705                |                    |                     | 705         | 276,9                            |
| CATALUNYA          |                    | 426                | 5                   | 431         | 98,7                             |
| C. VALENCIANA      | 510                |                    |                     | 510         | 132,2                            |
| EXTREMADURA        | 426                |                    |                     | 426         | 401,2                            |
| GALÍCIA            | 566                |                    |                     | 566         | 207,2                            |
| MADRID             |                    | 103                | 3                   | 106         | 77,9                             |
| MURCIA             | 197                |                    |                     | 197         | 188,4                            |
| NAVARRA            |                    | 37                 | 3                   | 40          | 132,5                            |
| EUSKADI            |                    | 257                | 2                   | 259         | 123,1                            |
| RIOJA (LA)         |                    | 17                 | 4                   | 21          | 138,1                            |
| CEUTA MELILLA      | 85                 |                    |                     | 85          | 684,2                            |

TABLE 2. PERIOD 94-99

| AUTONOMOUS REGIONS | OBJECTIVE 1 (MECU) | OBJECTIVE 2 (MECU) | OBJECTIVE 5b (MECU) | ERDF (MECU) | ERDF PER CAPITA (ECU per capita) |
|--------------------|--------------------|--------------------|---------------------|-------------|----------------------------------|
| ANDALUSIA          | 1692               |                    |                     | 1692        | 243,8                            |
| ARAGÓ              |                    | 49,4               | 72,8                | 122,2       | 112,3                            |
| ASTURIES           | 234                |                    |                     | 234         | 213,9                            |
| BALEARS            |                    | 8,8                | 12,2                | 21          | 67,9                             |
| CANÀRIAS           | 390                |                    |                     | 390         | 261,1                            |
| CANTABRIA          | 105                |                    |                     | 105         | 199,1                            |
| CAS.-LA MANXA      | 416                |                    |                     | 416         | 250,8                            |
| CASTILLA-LLEÓ      | 600                |                    |                     | 600         | 235,7                            |
| CATALUNYA          |                    | 402,2              | 36                  | 438,2       | 100,3                            |
| C. VALENCIANA      | 607                |                    |                     | 607         | 157,4                            |
| EXTREMADURA        | 382                |                    |                     | 382         | 359,7                            |
| GALÍCIA            | 727                |                    |                     | 727         | 266,1                            |
| MADRID             |                    | 113,7              | 13,2                | 126,9       | 93,3                             |
| MURCIA             | 197                |                    |                     | 197         | 188,4                            |
| NAVARRA            |                    | 17,7               | 12,1                | 29,8        | 98,7                             |
| EUSKADI            |                    | 267,8              | 4,5                 | 272,3       | 129,4                            |
| RIOJA (LA)         |                    | 10,5               | 10,1                | 20,6        | 135,4                            |
| CEUTA MELILLA      | 38                 |                    |                     | 38          | 305,9                            |

Specifically, measures of concentration are calculated with the sole objective of underlining the differences in ERDF concentration per capita, assigned by the European Union to the Autonomous Regions during the two periods under study. A purely quantitative calculation is performed of the differences, without entering into the analysis of the volume of projects financed in the different Autonomous Regions.

The indicators presented are measures derived from the concentration curve, since the Lorenz Diagram, with an initial graphic approach, allows us to visualise the existence of greater or lesser concentration according to the degree of convexity of the curve.

From this representation distances of interest arise between the straight line of equal distribution and the curve which reflect the inequality in the distribution of the ERDF funds per capita, always taking into account only the population assigned for objectives 1, 2 and 5b. The surface area separating the straight line from the curve is a good measure of concentration of the variable.

Taking into account the empirical observation of the data and the economic nature of the ERDF variable per capita, different theoretical functions of concentration are estimated:

- Kakwani-Podder model (1973):  $q(p) = p^\alpha \cdot e^{-\beta(1-p)}$  with  $\alpha \geq 1$   $\beta > 0$
- Kakwani model (1980):  $q(p) = p - A \cdot p^\alpha \cdot (1-p)^\beta$  with  $A, \alpha$  and  $\beta > 0$
- Gupta model (1984):  $q(p) = p \cdot A^{p-1}$  with  $A > 1$

The three equations possess the usual properties of a concentration curve:

- Range between 0 and 1:  $p \in (0,1) \rightarrow q(p) \in (0,1)$
- Increasing monotony:  $q'(p) \geq 0$
- Convexity:  $q''(p) \geq 0$

In addition these are equations which are highly operative for the calculation of the different indicators of concentration.

In the context of this study, identification in terms of random variable is applied to  $p$  as the fraction of population up to a level  $x$ , and  $q(p)$  as the fraction of ERDF funds accumulated up to level  $x$  distributions being ordered in terms of per capita.

The models are estimated using the squared minimums after conversion method:

- $\ln q(p) = \alpha \ln p + \beta (p-1) + \varepsilon$
- $\ln (p-q(p)) = \ln A + \alpha \ln p + \beta \ln (1-p) + \varepsilon$
- $\ln q(p) - \ln p = \ln A * (p-1) + \varepsilon$

These models have been chosen, firstly because they were created as concentration curves that allow the calculation of measures of inequality in the distribution of funds, and secondly because they are models which can be suitably adapted to the data presented.

## **CONCENTRATION MEASURES USED**

From the estimations concentration measures have been calculated which are obtained from the curves and which allow the quantitative calculation of the differences in, and concentration of, the ERDF funds per capita during the two periods under consideration. So they show a greater concentration when the value that they take is greater and therefore the greater the inequality existing in the distribution of the ERDF funds per capita.

1.- g Index.

Gini's coefficient of concentration, which is well known, and corresponds to double the area enclosed between the two lines of distribution, that is, double the average of all the distances between population and ERDF accumulation, as shown by graph 1.

$$g = 2E(p-q(p)) = 1 - 2E(q(p))$$

The expression of the index in the models considered takes on the following form:

Calculation of the Gini (g) index.

|                |                                                                    |
|----------------|--------------------------------------------------------------------|
| Kakwani-Podder | $1 - 2e^{-\beta} \sum_{i=0}^{\infty} \frac{\beta^i}{(a+1+i)!}$     |
| Kakwani        | $2A B(\alpha+1, \beta+1)$ ; with $B(\alpha+1, \beta+1)$ Beta Euler |
| Gupta          | $\frac{A \ln^2 A - 2A \ln A + 2A - 2}{A \ln^2 A}$                  |

## 2. - P Index

The P for Pietra coefficient is associated to the greater distance existing between the population and ERDF accumulations, a distance which is observed in the ERDF volume expected:

$$P = p_{\mu} - q(p_{\mu})$$

It is known that the concentration curve has a unitary gradient at the point  $((p_i, q(p_i)))$ , the moment in which the distances between the two lines is at its maximum (Graph 2).

$$\max [F_{\xi}(x) - q_{\xi}(x)] = p_{\mu} - q(p_{\mu}) \rightarrow q'(p) = 1$$

The coefficient P is normally used as the lowest level in the Gini index, at the same time that it responds to the double of the area of the greatest triangle that can be inscribed within the figure, i.e., that it coincides with half of the average relative difference and which in any case fulfils that  $P = \frac{DMR}{2} \leq g$

### 3.- d\* Index

Picks up the lack of phasing between the accumulated population and ERDF both in the mean (Ml) and in the median (ME). On the one hand,  $p(Ml)-0.5$  measures the inequality between two groups with equal ERDF and on the other,  $0.5-q(p(ME))$  measures the inequality of the two groups with equal population, both correspond with the distances which separate the line of equal distribution and the concentration curve from the geometrical centre of the graph (Graph 3), its simple aggregation leads us to the index:

$$d^* = p(Ml) - q(p(Me))$$

Its usage is not widely extended and it is rarely used in theoretical studies on concentration.

### 4.- d' Index

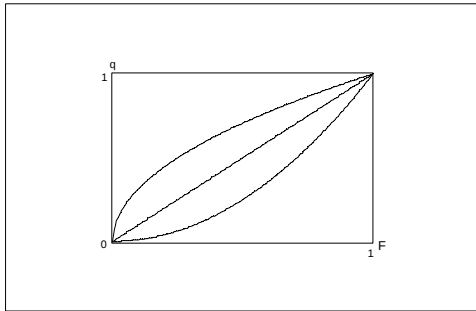
In the same way that we have considered central distances in the curve, it makes sense to measure the inequality gap that exists in the first quartile ( $0.25-q(p(Q1))$ ) and in the third quartile ( $0.75-q(p(Q3))$ ) (Graph 4.) The sum of these two distances gives sense to the d' coefficient:

$$d'=1 - [q(p(Q1)) + q(p(Q3))]$$

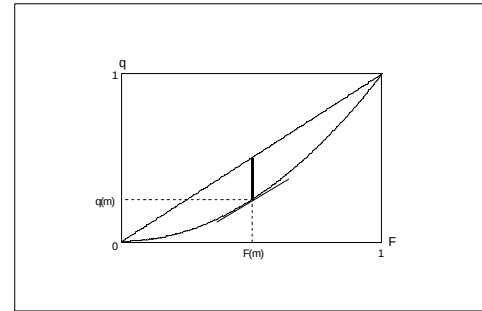
This is not a very widely used indicator either, its advantage lies in the fact that it admits the generalisation of any of the other quartiles, and in addition its calculation is immediate in any concentration function.

Graph 1: g Index

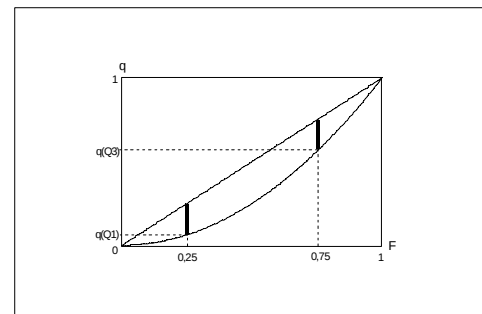
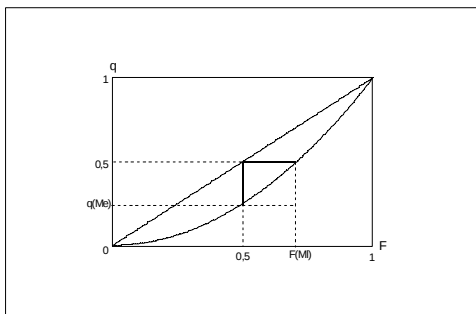
Graph 2: P\_Index



Graph 3: d\* Index



Graph 4: d' Index



## CONCENTRATION MODEL ESTIMATES

The three models offer adaptations of quality and an elevated degree of adherence for the two periods considered. Below we present the results of the estimates of the three models in tables 1, 2 and 3.

Table 1: Results of the Kakwani-Podder model estimation

|           | Predictor   | Coef          | DesvEst | razón-t |
|-----------|-------------|---------------|---------|---------|
| 1989-1993 | Ln p        | 1,32011       | 0,04609 | 28,64   |
|           | p-1         | 0,5071        | 0,1273  | 3,98    |
|           | s = 0,1280  | F = 3.110,36  |         |         |
| 1994-1999 | Ln p        | 1,07240       | 0,01389 | 77,22   |
|           | p-1         | 0,68232       | 0,03832 | 17,81   |
|           | s = 0,03935 | F = 27.035,42 |         |         |

|  |  |
|--|--|
|  |  |
|--|--|

Table 2: Results of the Kakwani model estimation

|           | Predictor                                           | Coef     | DesvEst | razón-t |
|-----------|-----------------------------------------------------|----------|---------|---------|
| 1989-1993 | Constante                                           | -0,34140 | 0,03357 | -10,17  |
|           | Ln p                                                | 0,97566  | 0,01561 | 62,52   |
|           | Ln (1-p)                                            | 0,78323  | 0,01351 | 57,98   |
|           | s = 0,06175    R-cda = 99,7%    R-cda(ajda) = 99,6% |          |         |         |
| 1994-1999 | Constante                                           | -0,59677 | 0,07352 | -8,12   |
|           | Ln p                                                | 0,96058  | 0,03179 | 30,22   |
|           | Ln (1-p)                                            | 0,90906  | 0,03651 | 24,90   |
|           | s = 0,1177    R-cda = 98,6%    R-cda(ajda) = 98,3%  |          |         |         |

Table 3: Results of the Gupta model estimation

|           | Predictor                 | Coef    | DesvEst | razón-t |
|-----------|---------------------------|---------|---------|---------|
| 1989-1993 | p-1                       | 1,3137  | 0,1014  | 12,96   |
|           | s = 0,2489    F = 167,84  |         |         |         |
| 1994-1999 | p-1                       | 0,86511 | 0,02463 | 35,12   |
|           | s = 0,06271    F= 1233,74 |         |         |         |

## VALUES OF THE FUNCTIONS AT CRITICAL POINTS

Once the models were estimated, we have calculated the value of the functions of concentration at critical points such as the median, the mean and the quartiles, which are presented in tables 4, 5 and 6.

Table 4: Value of the functions at critical points according to the Kakwani-Podder model

|       |      | $\mu$ | $Q_1$ | Me    | $Q_3$ | MI    |
|-------|------|-------|-------|-------|-------|-------|
| 89-93 | p    | 0,520 | 0,250 | 0,500 | 0,750 | 0,676 |
|       | q(p) | 0,330 | 0,109 | 0,310 | 0,588 | 0,500 |
| 93-99 | p    | 0,535 | 0,250 | 0,500 | 0,750 | 0,655 |

|  |      |       |       |       |       |       |
|--|------|-------|-------|-------|-------|-------|
|  | q(p) | 0,372 | 0,135 | 0,338 | 0,619 | 0,500 |
|--|------|-------|-------|-------|-------|-------|

Table 5: Value of the functions at critical points according to the Kakwani model

|       |      | $\mu$ | $Q_1$ | Me    | $Q_3$ | MI    |
|-------|------|-------|-------|-------|-------|-------|
| 89-93 | p    | 0,555 | 0,250 | 0,500 | 0,750 | 0,697 |
|       | q(p) | 0,342 | 0,103 | 0,289 | 0,568 | 0,500 |
| 93-99 | p    | 0,513 | 0,250 | 0,500 | 0,750 | 0,645 |
|       | q(p) | 0,363 | 0,138 | 0,349 | 0,631 | 0,500 |

Table 6: Value of the functions at critical points according to the Gupta model

|       |      | $\mu$ | $Q_1$ | Me    | $Q_3$ | MI    |
|-------|------|-------|-------|-------|-------|-------|
| 89-93 | p    | 0,570 | 0,250 | 0,500 | 0,750 | 0,725 |
|       | q(p) | 0,324 | 0,093 | 0,259 | 0,540 | 0,500 |
| 93-99 | p    | 0,550 | 0,250 | 0,500 | 0,750 | 0,667 |
|       | q(p) | 0,372 | 0,130 | 0,324 | 0,604 | 0,500 |

The values obtained in the three functions of concentration for the critical points considered are very close, and therefore they lead us to very similar conclusions.

Thus for example, if we consider the critical point of the median of the distribution, as a value which differentiates the total of communities in two groups (in the first group the volume of funds does not reach half of the total and in the second it exceeds half), practically 50% of the communities have received a volume of funds above the total median in the second period. Continuing with this line, and taking the median as the dividing point of the groups, we can establish relationships between the volume of ERDF funds in each group and the volume of funds of all the communities. The values obtained for the three functions are presented in tables 7, 8 and 9.

Table 7: Kakwani-Podder model

|       | $\frac{1-q(p_{\mu})}{1-p_{\mu}}$ | $\frac{p_{\mu}}{q(p_{\mu})}$ | $\frac{1-q(p_{\mu})}{q(p_{\mu})} * \frac{p_{\mu}}{1-p_{\mu}}$ |
|-------|----------------------------------|------------------------------|---------------------------------------------------------------|
| 89-93 | 1.39                             | 1.57                         | 2.18                                                          |
| 94-99 | 1.35                             | 1.43                         | 1.93                                                          |

Table 8: Kakwani model

|       | $\frac{1-q(p_{\mu})}{1-p_{\mu}}$ | $\frac{p_{\mu}}{q(p_{\mu})}$ | $\frac{1-q(p_{\mu})}{q(p_{\mu})} * \frac{p_{\mu}}{1-p_{\mu}}$ |
|-------|----------------------------------|------------------------------|---------------------------------------------------------------|
| 89-93 | 1.47                             | 1.62                         | 2.38                                                          |
| 94-99 | 1.30                             | 1.41                         | 1.83                                                          |

Table 9: Gupta Model

|       | $\frac{1-q(p_{\mu})}{1-p_{\mu}}$ | $\frac{p_{\mu}}{q(p_{\mu})}$ | $\frac{1-q(p_{\mu})}{q(p_{\mu})} * \frac{p_{\mu}}{1-p_{\mu}}$ |
|-------|----------------------------------|------------------------------|---------------------------------------------------------------|
| 89-93 | 1.57                             | 1.75                         | 2.74                                                          |
| 94-99 | 1.39                             | 1.47                         | 2.04                                                          |

In the first five year period and for the Kakwani model the average volume of funds received by the communities corresponding to the group of greatest volume, exceeds by 2.38 times that of the group of lowest volume, and presents an average funds volume which is 1.47 times greater than the total volume of funds.

As regards the second five year period, these differences are reduced. We also observe that the same conclusions are reached with the other two models.

In addition, the median in the three concentration models analysed, discriminates in two equal groups the target population and analyses in each of them the value of the volume of the funds received. The period with the least concentration is the second five year period where it can be seen that the disparity between the volume of funds received by one group or another is the lesser of the two periods. Thus the communities situated above the median in the first five year period absorb 28.90% of the volume of funds, and in the second five

year period, they absorb 34.93%. The same conclusion is reached through any of the three models analysed.

## MEASURES OF CONCENTRATION

To follow we present the calculation of the different measures of concentration for the three models considered.

Table 10. Concentration measures for the Kakwani-Podder model.

|       | P     | d*    | d'    | g     |
|-------|-------|-------|-------|-------|
| 89-93 | 0,189 | 0,365 | 0,301 | 0,260 |
| 94-99 | 0,162 | 0,316 | 0,245 | 0,216 |

Table 11. Concentration measures for the Kakwani model

|       | P     | d*    | d'    | g     |
|-------|-------|-------|-------|-------|
| 89-93 | 0,213 | 0,407 | 0,327 | 0,291 |
| 94-99 | 0,150 | 0,295 | 0,230 | 0,205 |

Table 12. Concentration measures for the Gupta model

|       | P     | d*    | d'    | g     |
|-------|-------|-------|-------|-------|
| 89-93 | 0,246 | 0,472 | 0,366 | 0,324 |
| 94-99 | 0,177 | 0,342 | 0,265 | 0,235 |

It is possible to observe how the indices derived from the three curves indicate that the tendency of the concentration is lesser in the second period from 94-99 than in the first period 89-93. Taking into account that in the two five year periods and in the three functions, the values are low, i.e., the inequality is not very great. The second period presents lesser inequality in the distribution of the ERDF funds among the populations eligible for the objectives.

## CONCLUSIONS

In the concentration curves representation for the two periods under study, and for the three models considered, according to figures 1, 2 and 3, we can see how the ERDF funds concentration per capita has decreased in the second five year period with respect to the first, as the measures previously described indicate. Thus, the curve for the 94-99 period is much closer to the imaginary line of equal distribution, and therefore less inequality exists in the distribution of the funds. We can conclude that with the application of the Community Support Framework for this second five year period, the difference existing in the assignation of funds to the Autonomous Regions of the State of Spain has reduced with respect to the previous period.

This study corroborates the conclusions of the European Commission with representation in Barcelona, according to which the reduction of ERDF per capita in the second five year period is palpable in the Spanish Autonomous Regions, in which it has been managed to reduce the inequality of the distribution of the ERDF funds per capita amongst the eligible populations.

FIGURE 1: KAKWANI-PODDER MODEL CONCENTRATION CURVES

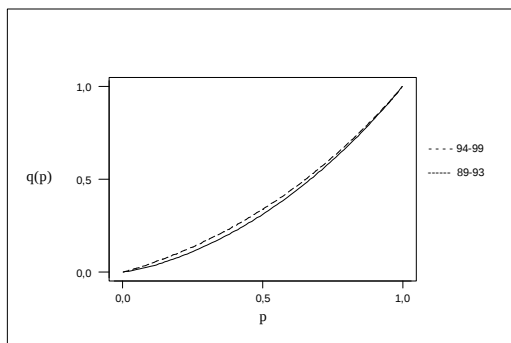


FIGURE 2. KAKWANI MODEL CONCENTRATION CURVES

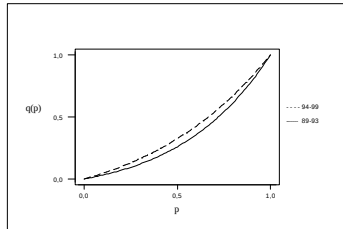
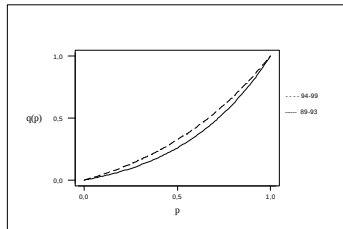


FIGURE 3. GUPTA MODEL CONCENTRATION CURVES



I. Estimation of the concentration curves Kawanni-Podder model:

$$q(p)_{89-93} = p^{1,3201} \cdot e^{-0,5071(1-p)}$$

$$q(p)_{94-99} = p^{1,0724} \cdot e^{-0,6832(1-p)}$$

| p  | q(p) <sub>89-93</sub> | q(p) <sub>94-99</sub> | p   | q(p) <sub>89-93</sub> | q(p) <sub>94-99</sub> |
|----|-----------------------|-----------------------|-----|-----------------------|-----------------------|
| 2  | 0,01                  | 0,00139               | 52  | 0,51                  | 0,32066               |
| 3  | 0,02                  | 0,00348               | 53  | 0,52                  | 0,33066               |
| 4  | 0,03                  | 0,00597               | 54  | 0,53                  | 0,34080               |
| 5  | 0,04                  | 0,00877               | 55  | 0,54                  | 0,35109               |
| 6  | 0,05                  | 0,01184               | 56  | 0,55                  | 0,36153               |
| 7  | 0,06                  | 0,01514               | 57  | 0,56                  | 0,37212               |
| 8  | 0,07                  | 0,01865               | 58  | 0,57                  | 0,38285               |
| 9  | 0,08                  | 0,02235               | 59  | 0,58                  | 0,39373               |
| 10 | 0,09                  | 0,02625               | 60  | 0,59                  | 0,40477               |
| 11 | 0,10                  | 0,03032               | 61  | 0,60                  | 0,41595               |
| 12 | 0,11                  | 0,03456               | 62  | 0,61                  | 0,42729               |
| 13 | 0,12                  | 0,03896               | 63  | 0,62                  | 0,43878               |
| 14 | 0,13                  | 0,04352               | 64  | 0,63                  | 0,45042               |
| 15 | 0,14                  | 0,04824               | 65  | 0,64                  | 0,46222               |
| 16 | 0,15                  | 0,05311               | 66  | 0,65                  | 0,47418               |
| 17 | 0,16                  | 0,05812               | 67  | 0,66                  | 0,48629               |
| 18 | 0,17                  | 0,06329               | 68  | 0,67                  | 0,49857               |
| 19 | 0,18                  | 0,06859               | 69  | 0,68                  | 0,51100               |
| 20 | 0,19                  | 0,07404               | 70  | 0,69                  | 0,52359               |
| 21 | 0,20                  | 0,07963               | 71  | 0,70                  | 0,53634               |
| 22 | 0,21                  | 0,08536               | 72  | 0,71                  | 0,54926               |
| 23 | 0,22                  | 0,09123               | 73  | 0,72                  | 0,56234               |
| 24 | 0,23                  | 0,09724               | 74  | 0,73                  | 0,57558               |
| 25 | 0,24                  | 0,10338               | 75  | 0,74                  | 0,58899               |
| 26 | 0,25                  | 0,10966               | 76  | 0,75                  | 0,60257               |
| 27 | 0,26                  | 0,11607               | 77  | 0,76                  | 0,61632               |
| 28 | 0,27                  | 0,12262               | 78  | 0,77                  | 0,63023               |
| 29 | 0,28                  | 0,12931               | 79  | 0,78                  | 0,64432               |
| 30 | 0,29                  | 0,13613               | 80  | 0,79                  | 0,65858               |
| 31 | 0,30                  | 0,14308               | 81  | 0,80                  | 0,67301               |
| 32 | 0,31                  | 0,15017               | 82  | 0,81                  | 0,68762               |
| 33 | 0,32                  | 0,15739               | 83  | 0,82                  | 0,70240               |
| 34 | 0,33                  | 0,16475               | 84  | 0,83                  | 0,71736               |
| 35 | 0,34                  | 0,17225               | 85  | 0,84                  | 0,73249               |
| 36 | 0,35                  | 0,17987               | 86  | 0,85                  | 0,74781               |
| 37 | 0,36                  | 0,18764               | 87  | 0,86                  | 0,76331               |
| 38 | 0,37                  | 0,19554               | 88  | 0,87                  | 0,77898               |
| 39 | 0,38                  | 0,20358               | 89  | 0,88                  | 0,79485               |
| 40 | 0,39                  | 0,21175               | 90  | 0,89                  | 0,81089               |
| 41 | 0,40                  | 0,22006               | 91  | 0,90                  | 0,82713               |
| 42 | 0,41                  | 0,22851               | 92  | 0,91                  | 0,84355               |
| 43 | 0,42                  | 0,23709               | 93  | 0,92                  | 0,86016               |
| 44 | 0,43                  | 0,24581               | 94  | 0,93                  | 0,87696               |
| 45 | 0,44                  | 0,25468               | 95  | 0,94                  | 0,89395               |
| 46 | 0,45                  | 0,26368               | 96  | 0,95                  | 0,91113               |
| 47 | 0,46                  | 0,27282               | 97  | 0,96                  | 0,92851               |
| 48 | 0,47                  | 0,28211               | 98  | 0,97                  | 0,94609               |
| 49 | 0,48                  | 0,29153               | 99  | 0,98                  | 0,96386               |
| 50 | 0,49                  | 0,30110               | 100 | 0,99                  | 0,98183               |
| 51 | 0,50                  | 0,31081               | 101 | 1,00                  | 1,00000               |

## II. Estimation of the concentration curves Kawanni model:

$$q(p)_{89-93} = p - 0,710774 \cdot p^{0,97566} \cdot (1-p)^{0,78323}$$

$$q(p)_{94-99} = p - 0,550587 \cdot p^{0,96058} \cdot (1-p)^{0,90906}$$

| p  | q(p) <sub>89-93</sub> | q(p) <sub>94-99</sub> | p   | q(p) <sub>89-93</sub> | q(p) <sub>94-99</sub> |
|----|-----------------------|-----------------------|-----|-----------------------|-----------------------|
| 2  | 0,01                  | 0,00211               | 52  | 0,51                  | 0,29925               |
| 3  | 0,02                  | 0,00461               | 53  | 0,52                  | 0,30866               |
| 4  | 0,03                  | 0,00732               | 54  | 0,53                  | 0,31821               |
| 5  | 0,04                  | 0,01022               | 55  | 0,54                  | 0,32792               |
| 6  | 0,05                  | 0,01328               | 56  | 0,55                  | 0,33777               |
| 7  | 0,06                  | 0,01649               | 57  | 0,56                  | 0,34778               |
| 8  | 0,07                  | 0,01985               | 58  | 0,57                  | 0,35793               |
| 9  | 0,08                  | 0,02336               | 59  | 0,58                  | 0,36824               |
| 10 | 0,09                  | 0,02700               | 60  | 0,59                  | 0,37871               |
| 11 | 0,10                  | 0,03078               | 61  | 0,60                  | 0,38933               |
| 12 | 0,11                  | 0,03470               | 62  | 0,61                  | 0,40011               |
| 13 | 0,12                  | 0,03875               | 63  | 0,62                  | 0,41105               |
| 14 | 0,13                  | 0,04293               | 64  | 0,63                  | 0,42215               |
| 15 | 0,14                  | 0,04724               | 65  | 0,64                  | 0,43341               |
| 16 | 0,15                  | 0,05169               | 66  | 0,65                  | 0,44484               |
| 17 | 0,16                  | 0,05627               | 67  | 0,66                  | 0,45643               |
| 18 | 0,17                  | 0,06097               | 68  | 0,67                  | 0,46820               |
| 19 | 0,18                  | 0,06581               | 69  | 0,68                  | 0,48014               |
| 20 | 0,19                  | 0,07078               | 70  | 0,69                  | 0,49225               |
| 21 | 0,20                  | 0,07587               | 71  | 0,70                  | 0,50454               |
| 22 | 0,21                  | 0,08110               | 72  | 0,71                  | 0,51701               |
| 23 | 0,22                  | 0,08645               | 73  | 0,72                  | 0,52966               |
| 24 | 0,23                  | 0,09193               | 74  | 0,73                  | 0,54250               |
| 25 | 0,24                  | 0,09754               | 75  | 0,74                  | 0,55553               |
| 26 | 0,25                  | 0,10329               | 76  | 0,75                  | 0,56875               |
| 27 | 0,26                  | 0,10916               | 77  | 0,76                  | 0,58217               |
| 28 | 0,27                  | 0,11516               | 78  | 0,77                  | 0,59579               |
| 29 | 0,28                  | 0,12129               | 79  | 0,78                  | 0,60962               |
| 30 | 0,29                  | 0,12755               | 80  | 0,79                  | 0,62366               |
| 31 | 0,30                  | 0,13394               | 81  | 0,80                  | 0,63792               |
| 32 | 0,31                  | 0,14047               | 82  | 0,81                  | 0,65240               |
| 33 | 0,32                  | 0,14712               | 83  | 0,82                  | 0,66712               |
| 34 | 0,33                  | 0,15391               | 84  | 0,83                  | 0,68207               |
| 35 | 0,34                  | 0,16083               | 85  | 0,84                  | 0,69728               |
| 36 | 0,35                  | 0,16788               | 86  | 0,85                  | 0,71274               |
| 37 | 0,36                  | 0,17506               | 87  | 0,86                  | 0,72846               |
| 38 | 0,37                  | 0,18238               | 88  | 0,87                  | 0,74447               |
| 39 | 0,38                  | 0,18983               | 89  | 0,88                  | 0,76078               |
| 40 | 0,39                  | 0,19742               | 90  | 0,89                  | 0,77740               |
| 41 | 0,40                  | 0,20514               | 91  | 0,90                  | 0,79435               |
| 42 | 0,41                  | 0,21300               | 92  | 0,91                  | 0,81167               |
| 43 | 0,42                  | 0,22100               | 93  | 0,92                  | 0,82937               |
| 44 | 0,43                  | 0,22913               | 94  | 0,93                  | 0,84750               |
| 45 | 0,44                  | 0,23740               | 95  | 0,94                  | 0,86612               |
| 46 | 0,45                  | 0,24581               | 96  | 0,95                  | 0,88529               |
| 47 | 0,46                  | 0,25436               | 97  | 0,96                  | 0,90511               |
| 48 | 0,47                  | 0,26305               | 98  | 0,97                  | 0,92573               |
| 49 | 0,48                  | 0,27189               | 99  | 0,98                  | 0,94745               |
| 50 | 0,49                  | 0,28086               | 100 | 0,99                  | 0,97090               |
| 51 | 0,50                  | 0,28998               | 101 | 1,00                  | 1,00000               |



### III. Estimation of the concentration curves Gupta model:

$$q(p)_{89-93} = p \cdot 3,719911^{p-1}$$

$$q(p)_{94-99} = p \cdot 2,375267^{p-1}$$

| 93 | p    |         |  | q(p) <sub>89-93</sub> | q(p) <sub>94-99</sub> | p   |      |         | q(p) <sub>89-93</sub> | q(p) <sub>94-99</sub> |
|----|------|---------|--|-----------------------|-----------------------|-----|------|---------|-----------------------|-----------------------|
|    |      |         |  |                       |                       |     |      |         |                       |                       |
| 2  | 0,01 | 0,00272 |  | 0,00425               |                       | 52  | 0,51 | 0,26792 |                       | 0,33379               |
| 3  | 0,02 | 0,00552 |  | 0,00857               |                       | 53  | 0,52 | 0,27679 |                       | 0,34329               |
| 4  | 0,03 | 0,00839 |  | 0,01296               |                       | 54  | 0,53 | 0,28584 |                       | 0,35293               |
| 5  | 0,04 | 0,01133 |  | 0,01743               |                       | 55  | 0,54 | 0,29509 |                       | 0,36272               |
| 6  | 0,05 | 0,01435 |  | 0,02198               |                       | 56  | 0,55 | 0,30453 |                       | 0,37264               |
| 7  | 0,06 | 0,01745 |  | 0,02661               |                       | 57  | 0,56 | 0,31416 |                       | 0,38271               |
| 8  | 0,07 | 0,02063 |  | 0,03131               |                       | 58  | 0,57 | 0,32400 |                       | 0,39293               |
| 9  | 0,08 | 0,02389 |  | 0,03609               |                       | 59  | 0,58 | 0,33404 |                       | 0,40330               |
| 10 | 0,09 | 0,02723 |  | 0,04096               |                       | 60  | 0,59 | 0,34430 |                       | 0,41382               |
| 11 | 0,10 | 0,03066 |  | 0,04590               |                       | 61  | 0,60 | 0,35476 |                       | 0,42449               |
| 12 | 0,11 | 0,03417 |  | 0,05093               |                       | 62  | 0,61 | 0,36545 |                       | 0,43531               |
| 13 | 0,12 | 0,03777 |  | 0,05605               |                       | 63  | 0,62 | 0,37635 |                       | 0,44629               |
| 14 | 0,13 | 0,04146 |  | 0,06125               |                       | 64  | 0,63 | 0,38747 |                       | 0,45743               |
| 15 | 0,14 | 0,04523 |  | 0,06653               |                       | 65  | 0,64 | 0,39883 |                       | 0,46873               |
| 16 | 0,15 | 0,04911 |  | 0,07190               |                       | 66  | 0,65 | 0,41042 |                       | 0,48019               |
| 17 | 0,16 | 0,05307 |  | 0,07736               |                       | 67  | 0,66 | 0,42224 |                       | 0,49181               |
| 18 | 0,17 | 0,05714 |  | 0,08291               |                       | 68  | 0,67 | 0,43431 |                       | 0,50360               |
| 19 | 0,18 | 0,06130 |  | 0,08855               |                       | 69  | 0,68 | 0,44662 |                       | 0,51556               |
| 20 | 0,19 | 0,06556 |  | 0,09428               |                       | 70  | 0,69 | 0,45918 |                       | 0,52769               |
| 21 | 0,20 | 0,06992 |  | 0,10011               |                       | 71  | 0,70 | 0,47200 |                       | 0,53999               |
| 22 | 0,21 | 0,07439 |  | 0,10602               |                       | 72  | 0,71 | 0,48507 |                       | 0,55246               |
| 23 | 0,22 | 0,07896 |  | 0,11204               |                       | 73  | 0,72 | 0,49841 |                       | 0,56511               |
| 24 | 0,23 | 0,08364 |  | 0,11815               |                       | 74  | 0,73 | 0,51201 |                       | 0,57794               |
| 25 | 0,24 | 0,08843 |  | 0,12436               |                       | 75  | 0,74 | 0,52589 |                       | 0,59094               |
| 26 | 0,25 | 0,09333 |  | 0,13066               |                       | 76  | 0,75 | 0,54004 |                       | 0,60413               |
| 27 | 0,26 | 0,09835 |  | 0,13707               |                       | 77  | 0,76 | 0,55448 |                       | 0,61751               |
| 28 | 0,27 | 0,10348 |  | 0,14358               |                       | 78  | 0,77 | 0,56920 |                       | 0,63107               |
| 29 | 0,28 | 0,10874 |  | 0,15019               |                       | 79  | 0,78 | 0,58422 |                       | 0,64482               |
| 30 | 0,29 | 0,11411 |  | 0,15691               |                       | 80  | 0,79 | 0,59954 |                       | 0,65876               |
| 31 | 0,30 | 0,11960 |  | 0,16373               |                       | 81  | 0,80 | 0,61515 |                       | 0,67290               |
| 32 | 0,31 | 0,12523 |  | 0,17066               |                       | 82  | 0,81 | 0,63108 |                       | 0,68723               |
| 33 | 0,32 | 0,13097 |  | 0,17769               |                       | 83  | 0,82 | 0,64732 |                       | 0,70176               |
| 34 | 0,33 | 0,13685 |  | 0,18484               |                       | 84  | 0,83 | 0,66388 |                       | 0,71648               |
| 35 | 0,34 | 0,14287 |  | 0,19209               |                       | 85  | 0,84 | 0,68076 |                       | 0,73142               |
| 36 | 0,35 | 0,14901 |  | 0,19946               |                       | 86  | 0,85 | 0,69797 |                       | 0,74656               |
| 37 | 0,36 | 0,15530 |  | 0,20694               |                       | 87  | 0,86 | 0,71552 |                       | 0,76190               |
| 38 | 0,37 | 0,16172 |  | 0,21454               |                       | 88  | 0,87 | 0,73342 |                       | 0,77746               |
| 39 | 0,38 | 0,16829 |  | 0,22225               |                       | 89  | 0,88 | 0,75166 |                       | 0,79323               |
| 40 | 0,39 | 0,17500 |  | 0,23008               |                       | 90  | 0,89 | 0,77025 |                       | 0,80921               |
| 41 | 0,40 | 0,18186 |  | 0,23803               |                       | 91  | 0,90 | 0,78920 |                       | 0,82541               |
| 42 | 0,41 | 0,18887 |  | 0,24610               |                       | 92  | 0,91 | 0,80853 |                       | 0,84184               |
| 43 | 0,42 | 0,19604 |  | 0,25429               |                       | 93  | 0,92 | 0,82822 |                       | 0,85848               |
| 44 | 0,43 | 0,20336 |  | 0,26261               |                       | 94  | 0,93 | 0,84829 |                       | 0,87535               |
| 45 | 0,44 | 0,21084 |  | 0,27105               |                       | 95  | 0,94 | 0,86875 |                       | 0,89245               |
| 46 | 0,45 | 0,21848 |  | 0,27962               |                       | 96  | 0,95 | 0,88960 |                       | 0,90978               |
| 47 | 0,46 | 0,22629 |  | 0,28832               |                       | 97  | 0,96 | 0,91086 |                       | 0,92735               |
| 48 | 0,47 | 0,23427 |  | 0,29715               |                       | 98  | 0,97 | 0,93251 |                       | 0,94515               |
| 49 | 0,48 | 0,24242 |  | 0,30611               |                       | 99  | 0,98 | 0,95459 |                       | 0,96319               |
| 50 | 0,49 | 0,25074 |  | 0,31520               |                       | 100 | 0,99 | 0,97708 |                       | 0,98147               |
| 51 | 0,50 | 0,25924 |  | 0,32442               |                       | 101 | 1,00 | 1,00000 |                       | 1,00000               |

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