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A cluster analysis of Croatian counties as the base for an active demographic policy

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Abstract. This paper deals with Croatian counties cluster analysis as the base for developping a proactive demographic policy. Unfortunately, Croatia has no national demographic strategy and no national population policy is carried out. Some local governments are taking isolated policy measures but due to an unsystematic and distressed network at the national level it has to date given no significant effects. The Croatian nation is currently experiencing the initial process of demographic extinction. This process began even before the great emigration wave that started about a year and half ago. Since there are no financial resources for the simultaneous and complete implementation of an active demographic policy across the entire Croatian territory, this paper proposes a new approach. Namely, the main demographic indicators have been calculated and analyzed for each Croatian county. After that, using a multivariate methodology, fifteen demographic indicators that significantly differ from county to county were selected as criteria for clustering Croatian counties by k-means method. Clustering output defines several clusters consisting of a smaller number of counties with similar demographic characteristics. These clusters form a spatial county unit in which appropriate measures of an active demographic policy should be urgently implemented. In this way the process of active demographic policy can start with less financial resources and can be limited maybe only to spaces with poorest demographic characteristics. Moreover, the results of this study might very well stimulate "richer" government units to carry out the appropriate active demographic policy measures in their areas without waiting for the adoption of laws and regulations at the national state level.

Keywords: Croatian county depopulation process, net migration rate, ageing index, k-means method, Croatian counties cluster analysis

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1. Introduction

This paper is a part of ongoing national demographic research with the primary purpose of creating a base for an active demographic policy. Namely, Croatia has encroached on the doorstep of a demographic cataclysm and this paper, taking into account these circumstances, focuses its research "in medias res". There is no need for extensive citation of appropriate literature review as well as detailed presentation of theoretic background. The author of this article has long been involved in this issue and is one of the authors of The National Program for Demographic Development (National Program) [26].

This work is a direct continuation of the National Program and therefore it is necessary to consider all these facts and research mentioned in the National Program.

Back in January 1996, Croatian Parliament enacted the said National Program, but its implementation from the very beginning was obstructed due to chronic shortage of financial resources. As it was not implemented the Croatian nation has presently began the process of demographic extinction. The process of demographic extinction began even before the great emigration wave that started the last year and half. It is estimated that each year 30 000 citizens, predominantly young people, emigrate from Croatia. This is an estimate based on demographics data from the countries which Croatian emigrants reach [5]. This data is not precise because the Croatian citizens do not formally sign out when they emigrate. If the negative trends continue, Croatia will lose annually 50.000 of its domicile population due to natural increase rate and emigration. For a population that is among the oldest in the world [6], with 4.284,889 million inhabitants according to the last census, this represents an unsustainable situation for all the aspects of the national's social and economic survival.

There are numerous studies confirming that the unsolved financial situation, unemployment and bad housing status in Croatia are the main factors of emigrations and delay having children [22,23]. These main factors can and should be eliminated by fundamental structural changes at the national level. Indeed, this is confirmed by a typical "Croatian example" - the introduction of the three-year maternity leave, which has had a direct effect on positively natural increasing the natural rate in 1996 year after a number of years with a negative population growth. All the above mentioned confirms that Croatia knows how, can and must start implementing active demographic policy.

This is confirmed by studies of many authors with a review provided in the second part of the paper. The third part is focused on the demographic aging of the Croatian people with population movements treated in the fourth part. In the fifth part of the paper the multivariate analysis results of the Croatian Counties clustering are given. Before the references, at the end of the paper, conclusion remarks are offered.

2. Literature background

From various aspects and various profession criteria to which they belong, primarily domestic authors have written about active demographic policy. Particularly fertile period in which they published articles dealing with this issue was between the two last censuses (from 2001 to 2011).

The first group of authors includes all the authors that directly explore the overall development, depopulation and the possibility of revitalization [15,19,25,29,32,33, 34,36,38,40,42,44,45,47]. Almost all the authors confirmed that Croatia has unfavorable demographic indicators and trends and that goes to the depopulation and to the natural decline of the population. Moreover, they conclude that for the future of a Croatian population appropriate revival and active population policy are necessary.

The second group of authors considers balancing spatial mobility of the population and demographic contingent potential[1,2,3,11,16,18,20,24,28]. From the research, it is possible to confirm the prevailing phenomenon of negative migration balance in most Croatian municipalities and the decreasing fertile contingents of the population, which are important for the reproduction of the total population.

The third group of authors include those papers deal with models of Croatian population policy [16,41,42,43]. Those researches have resulted with proposals for stimulated Croatian population policy in the published papers, and later in the National Program for Demographic Development, adopted by the Croatian Parliament in 18 January 1996.

Estimates of future demographic extinction or potential revitalization must be based on population projections, which constitute the fourth group of works [21,27,46,47]. In particular, it is necessary to point out that none of the projections includes possible substitution of the population as the expected variation over long process of depopulation.

Given that wars lead to the greatest social and demographic destruction and essentially directed demographic developments after the wars, the demographic consequences of the aggression against Croatia at the beginning of the 1990s should be taken into consideration. Hence, the fifth group of authors [35,45], confirm the intensification of negative general demographic picture of Croatia.

The sixth group includes works with the general theoretical and conceptual approaches which are applicable in the present study [14,15,41,46,47], as well as the starting point for understanding the general legality of the earlier periods and setting key assumptions.

3. Croatian demographic aging

Unfortunately, Croatia is following all the demographic trends of the European Union (EU). Namely, EU is facing with the problem of the significant aging of the population. This demographic shift is inevitable consequence of the significant accomplishments of the greatly reduced mortality rates at work and, therefore, a longer life expectancy. It is, moreover accompanied by greatly reduced birth rates in almost all countries.

According to the Eurostat database for 1 January 2013 year, the Croatian population is among the oldest populations in the world with the median age greater than the median population age in the EU. The oldest average age in the EU has German with 45.3 years. Croatia population average age is only 11 month less than the German according the data in Table 1.

Census	Number of inhabitants	Average age of Croatian Population	Average age of Men	Average age of Women	The increase of age to the previous census (Croatian Population)
1961	4 159 696	32.5	30.5	33.3	-
1971	4 426 221	34.0	32.4	35.5	1.5
1981	4 601 469	35.4	33.8	37.1	1.4
1991	4 784 265	37.1	35.4	38.7	1.7
2001	4 437 460	39.3	37.5	41.0	2.2
2011	4 284 889	41.7	39.9	43.4	2.4

Source: Authors' calculations from the censuses of the Croatian Bureau of Statistics [8, 9]

Table 1: *Average age of Croatian Population by sex, 1961-2011*

The average age indicates the mean age of the total population in a certain area (country, town, etc.) and it is calculated as an arithmetic mean of the age of the total population [8, 9]. The most common indicators of aging population are ageing index and age coefficient.

The age coefficient is the percentage of the population aged 60 and over in the total population. It is a basic indicator in measuring the ageing level. When it exceeds 12%, it means that the population of a particular area entered the ageing process [6].

The ageing index is the percentage of the population aged 60 and over in the population aged 0-19. The index exceeding 40% indicates that the population of a particular area entered the ageing process.

Moreover, a large emigration wave of young and highly educated people in recent years is an additional strain on the ratio of active working people in the population and supported population ratio. This ratio is so deranged and one of the worst in Europe that suggests the possible collapse of the national pension system.
The fact that in the emigrant wave in recent years has been dominant young and highly educated people influences the deterioration of the educational structure of the population.

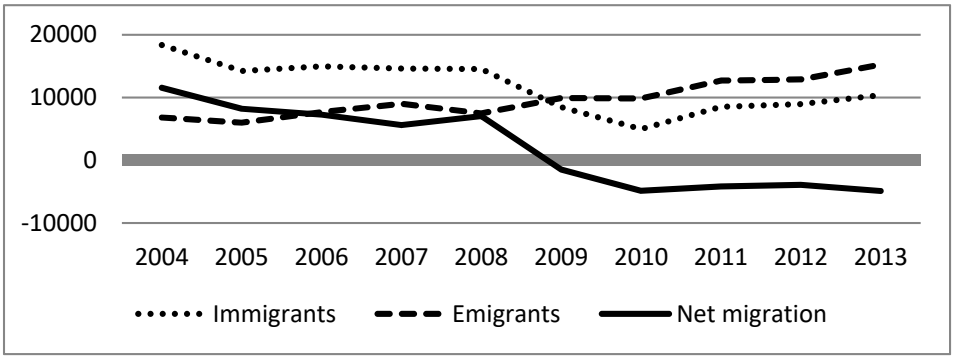
Census	Ageing index			Age coefficient		
	Total	Men	Women	Total	Men	Women
1953	27.9	22.2	33.8	10.3	8.8	11.6
1961	34.3	27.7	41.1	11.8	10.1	13.3
1971	47.2	38.5	56.2	15.0	12.9	16.9
1981	52.6	40.4	65.3	15.0	12.1	17.6
1991	66.7	50.8	83.3	17.7	14.3	21.0
2001	90.7	71.6	110.8	21.6	18.1	24.9
2011	115.0	92.3	139.0	24.1	20.5	27.4

Source: Authors' calculations based on the Censuses from 1953-2011, Croatian Bureau of Statistics[6]

Table 2: *Croatian Population Ageing index and Age coefficient*

4. Population movements

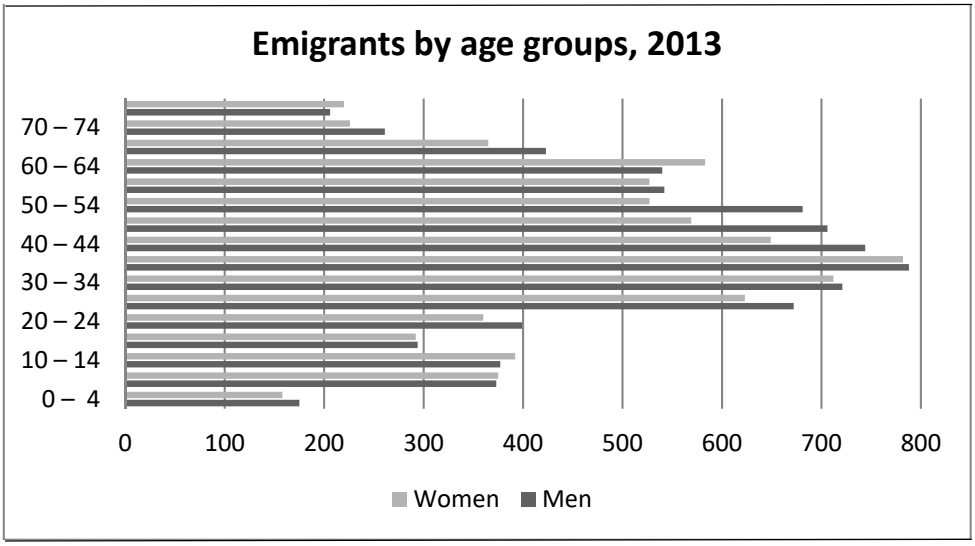
The net migration of population (migration balance) is the difference between the number of immigrants and emigrants of a particular area or country in a given period.
The contribution of migration to overall population growth or decline is due to positive or negative net migration. Moreover, the migration balance has a negative effects in Croatia reinforce the fact that the largest proportion of the emigration waves from the very beginning until today are young people. This is confirmed by data from the Figure 2.
Besides the negative emigrations effects, the Croatian population has an extremely negative natural change rate. The population natural change rate or so called the crude rate of natural change is the ratio of the natural change during the year (live births minus deaths) to the average population in that year. The value is expressed per 1 000 persons. The crude rate of natural change has constantly decreasing and the value of 5.0 in 1974 dropped to - 2.7 in 2014.



Source: Authors' creation according to Croatian Bureau of Statistics [13]

Figure 1: *Croatian Population migrations over the period from 2004-2013*

Due to the emigration of women who are predominantly of childbearing age, as can be seen in Figure 2, in the coming years an additional steep drop in the crude rate of natural change is expected.



Source: Authors' creation according to the Croatian Bureau of Statistics [7]

Figure 2: *Croatian Population emigrated abroad in 2013 by age and sex*

5. A cluster analysis of Croatian counties based on demographic criteria

Among the multivariate analysis methods and techniques, the k- means method has been chosen as the most appropriate for clustering of Croatian counties. Besides other advantages, the k-means method is especially effective because it provides opportunity that the number of clusters can be pre-determined in advance.
Generally, the k-means method is used for clustering partitions n objects into k clusters where each object belongs to the cluster with the nearest mean. This method produces exactly k different clusters of greatest possible distinction. The best number of clusters k leading to the greatest separation (distance) is not known as a priori and must be computed from the data. The objective of using the k-means method for clustering is to minimize total intra-cluster variance or the squared error function [5].
The k-means method algorithm takes place in several steps. The first one is clustering the data into k groups where k is predefined. In the second step, the algorithm randomly selects k points as cluster centers. The third step is to assign objects to their closest cluster center according to the Euclidean distance function. The fourth step involving the k-means method algorithm consists of calculating the centroid or mean of all objects in each cluster. Finally, the fifth step repeats steps 2, 3 and 4 until the same points are assigned to each cluster in consecutive rounds [30].
That's why the k-means method is a relatively an efficient clustering method. However, we need to specify the number of clusters, in advance. Unfortunately, there is no global theoretical method to find the optimal number of clusters. A practical approach is to compare the outcomes of multiple runs with different k and choose the best one based on a predefined criterion. In general, a large k probably decreases the error but increases the risk of overfitting. The k-means method output regularly includes analysis of variance F statistics. While these statistics are opportunistic (the procedure tries to form groups that do differ), the relative size of the statistics provides information on the contribution to the separation of each variable to the separation of the groups.

COUNTY	Age group (in %)			Average age of population	Ageing index (in %)	Maternal women with higher level of education	No. of children per women older of 15 year
	0-24	25-65	66 and more				
Republic of Croatia	27.03	56.08	16.88	41.7	115.0	34%	1.56%

County of Zagreb	28.07	56.95	14.96	40.6	100.1	30%	1.53%
County of Krapina-Zagorje	27.27	55.99	16.73	41.7	112.6	27%	1.62%
County of Sisak-Moslavina	25.81	55.46	18.71	43.0	131.1	32%	1.63%
County of Karlovac	24.07	55.62	20.30	44.0	149.0	32%	1.55%
County of Varaždin	27.46	56.54	15.99	41.2	107.3	29%	1.61%
County of Koprivnica-Križevci	27.65	55.44	16.89	41.6	110.5	25%	1.60%
County of Bjelovar-Bilogora	27.66	54.72	17.61	42.0	114.9	20%	1.68%
County of Primorje-Gorski Kotar	22.80	59.09	18.10	43.9	155.3	42%	1.35%
County of Lika-Senj	24.07	52.10	23.82	45.3	166.0	30%	1.72%
County of Virovitica-Podravina	28.67	54.86	16.45	41.2	103.3	18%	1.73%
County of Požega-Slavonia	30.24	52.54	17.21	40.9	99.2	22%	1.81%
County of Slavonski Brod-Posavina	30.59	52.66	16.74	40.6	96.5	20%	1.81%
County of Zadar	27.71	54.72	17.55	41.9	117.4	32%	1.73%
County of Osijek-Baranja	28.00	55.89	16.09	41.2	106.3	22%	1.64%
County of Šibenik-Knin	25.57	53.44	20.97	44.1	146.1	41%	1.76%

County of Vukovar-Sirmium	29.91	53.77	16.30	40.6	98.3	20%	1.81%
County of Split-Dalmatia	28.91	55.26	15.82	40.8	102.3	38%	1.65%
County of Istria	24.06	58.64	17.29	43.0	136.8	37%	1.45%
County of Dubrovnik-Neretva	28.35	54.58	17.05	41.5	109.4	39%	1.61%
County of Međimurje	29.45	55.71	14.82	40.0	91.8	21%	1,76%
City of Zagreb	25.76	57.80	16.42	41.6	118.9	49%	1.22%

Source: Authors' calculations based on data from the Croatian Bureau of Statistics [8]

Table 3: *Some age population indicators for the Croatian counties in 2013*

Therefore, the set of criteria for carrying out the clustering procedure is particularly important. In the first stage of clustering the Croatian counties, all demographic indicators monitored by Croatian Bureau of Statistics in 2013 were used as clustering criteria. Unfortunately, a greater number of these 57 demographic indicators were not statistically significant as a multivariate analysis criteria. Therefore, the clustering process was finally completed with 15 statistically significant criteria that were statistically significant as it is evident by the results shown in Table 4 and which also lists the ranking criteria themselves.

The complete Croatian counties clustering procedure based on 15 demographic criteria using the k-means method was carried out using the Statistical Package for Social Sciences (2010), SPSS for Windows (Version 20.0) [31].

The analysis of variance table with the k-means method criteria for clustering of Croatian counties is shown in the following table.

Criteria	F-ratio	Sign.
Share of population between 0-24 years old, 2013	5.775	.004
Share of population between 25-65 years old, 2013	6.592	.002
Mothers younger than 15 that gave birth in 2013	23.548	.000
Mothers between 15 and 19 that gave birth in 2013	18.262	.000
Mothers between 20 and 29 that gave birth in 2013	34.447	.000
Mothers between 30 and 39 that gave birth in 2013	56.856	.000
Mothers older than 40 that gave birth in 2013	9.101	.000
Mothers that gave birth first child in 2013	14.602	.000

Mothers that gave birth second child in 2013	2.882	.051
Mothers that gave birth third or more child in 2013	20.849	.000
Lower educated mothers that gave birth in 2013	22.068	.000
Higher educated mothers that gave birth in 2013	26.500	.000
Working active mothers that gave birth in 2013	9.646	.000
Mothers with personal income that gave birth in 2013	21.252	.000
Mothers without personal income that gave birth in 2013	9.862	.000

Source: Authors' calculations based on data from the Croatian Bureau of Statistics [5,6,7,8,9].

Table 4: *The Analysis of Variance (ANOVA) table with cluster analysis criteria*

The F tests should be uses only for descriptive purposes because the clusters have been chose to maximize the differences among cases in different clusters. The observed significance levels are not correct for this and thus cannot be interpreted as tests of the hypothesis that the cluster means are equal.

Clustering criteria definitions given in Table 4 are generally known except for two criteria: “Lower educated mothers that gave birth in 2013”and “Higher educated mothers that gave birth in 2013”. The first group "less educated mothers” are those who have completed at most a four-year vocational school or high school. The other group of “more educated mothers” are the those that have the higher education level.

According to Croatian Bureau of Statistics “Working active mothers” are those who work for their living (in paid employment or self-employment in a private or family business), persons who are looking for their first or new job and persons who interrupted their job due to serving a jail sentence or detention measures. “Mothers with personal income” are retired persons of all categories, beneficiaries of social welfare or persons who get their income from leasing land, houses, shops, workshops or other property. The initial number of clusters was determined in advance as required by the k-means method and the number of cases (counties) in each cluster is fairly uniform as it can be seen in Table 5. Namely, the area of each cluster determined by the k-means method output as area of several counties united by demographic criteria is not too big nor too small to be able to independently implement active demographic measures.

Number of Cluster	Number of Cases
1	4.00
2	4.00
3	3.00
4	2.00
5	2.00
6	6.00

Valid	21.00
Missing	0.00

Source: Authors' calculations based on data from the Croatian Bureau of Statistics [6,7,8,9,10]

Table 5: *Number of cases in each cluster determined by the k-means method*

Specific active demographic measures are suitable for certain demographic characteristics of each cluster will be the subject of the authors' future research within this ongoing project. The results of clustering the Croatian counties using the k-means method in the six unique spacious units, which are homogenous and their demographic indicators, are show in Table 6.

Cluster Membership			
Case Number	County	Cluster	Distance
1	County of Bjelovar-Bilogora	1	4.750
2	County of Slavonski Brod- Posavina	3	3.528
3	County of Dubrovnik-Neretva	2	2.739
4	City of Zagreb	4	6.782
5	County of Istria	5	5.745
6	County of Karlovac	6	7.814
7	County of Koprivnica-Križevci	1	5.879
8	County of Krapina- Zagorje	6	11.433
9	County of Lika-Senj	6	5.513
10	County of Međimurje	1	7.587
11	County of Osijek-Baranja	6	10.217
12	County of Požega-Slavonia	3	5.637
13	County of Primorje-Gorski Kotar	4	6.782
14	County of Sisak-Moslavina	6	8.508
15	County of Split-Dalmatia	2	5.292
16	County of Šibenik-Knin	2	7.810
17	County of Varaždin	6	8.290
18	County of Virovitica-Podravina	1	7.215
19	County of Vukovar-Sirmium	3	2.906
20	County of Zadar	2	5.244
21	County of Zagreb	5	5.745

Source: Authors' calculations based on data from the Croatian Bureau of Statistics [6,7,8,9,10]

Table 6: *Cluster analysis results as calculated by the authors using the SPSS with the numbers of Croatian Counties in each Cluster, according to the k-means method*

The first cluster consists of County of Bjelovar-Bilogora, County of Koprivnica-Križevci, County of Međimurje and County of Virovitica-Podravina. The second cluster comprises: County of Dubrovnik-Neretva, County of Split-Dalmatia, County of Šibenik-Knin and County of Zadar. This is followed by the third cluster comprising of County of Slavonski Brod-Posavina, County of Požega-Slavonia and County of Vukovar-Sirmium. In the fourth cluster are grouped: City of Zagreb, County and Primorje-Gorski Kotar. Fifth cluster consists of County of Istria and County of Zagreb. Finally, the sixth cluster includes: County of Karlovac, County of Krapina-Zagorje, County of Lika-Senj, County of Osijek-Baranja, County of Sisak-Moslavina and County of Varaždin.
The complete clustering procedure with the same database and the same set of criteria were carried out also using the hierarchial cluster method. Using the between-groups linkage and the interval Euclidean distance this method gave, as presented by its Dendrogram as output, exactly the same clustering results as the k-means method results presented in Table 6.

6. Conclusion remarks

The Croatian population is one of the oldest in the world with very unfavorable ageing index and age coefficient. Moreover, the negative crude rate of natural change and migration balance, which the greatest part are young and highly educated Croatian emigrants, made from year to year, Croatian demographic situation worse and worse.
Hence, this work aims to be a direct continuation of the National Program. It is therefore necessary to consider all these facts and research results mentioned in the National Program, based upon which the Croatia Government is in the position of knowing how, that it can and it must decide to start applying an active demographic policy.
The scientific contribution of this research is in the clustering of Croatian counties where the results enable and encourage prompt implementation of the National Program at the levels lower than the national level. The results of Croatian Counties clustering by using the k-means method provides the clusters that form a spatial county units possessing the similar demographic indicators according to which appropriate measures of an active demographic policy should be urgently implemented. In this way the process of active demographic policy may start with less financial resources and can be limited perhaps only to places with the worst demographic characteristics.
The results of the cluster analysis of Croatian counties in this paper can be the basis of an active demographic policy. Moreover, the results of this study may very well stimulate the more prosperous administrative units to apply appropriate active demographic policy measures in their areas without waiting for the

adoption of laws and regulations at the national level of government. This research belongs in part to the ongoing demographic project and in future studies, the authors will look into the specific demographic characteristics of the six clusters, established in this paper for the purpose of proposing specific and appropriate active demographic policy measures for each cluster.

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