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Analytical Study of Pyramidal Hierarchy of Urban Centers Case Study the Wilaya of Constantine

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Abstract

This paper aims to study the hierarchy of urban centers in the Wilaya of Constantine. The question of this research is how the urban residents are distributed and aggregated across different-sized cities in the period from 1966 to 2020. This question can be addressed by studying urban system or Zipf's law and focus on whether cities are evenly ranked by size.

We have found that the urban system of the Wilaya of Constantine has a known and remarkable mutation over the last 54 years. Before 1987 the urban system of Constantine was characterized by the predominance of the city of Constantine and the array of small combinations. After 1987, a reverse trend is observed after the transfer of the demographic surplus from the first city of Constantine to the satellite cities. However, the urban system of the Wilaya is in harmony with the right adjustments and tendency towards balance.

Key words: Zipf Law, Uierarchy of urban, Urban system, Wilaya of Constantine.

INTRODUCTION

The Observation of the size of cities in the world has made it possible to highlight certain statistical regularities in their hierarchical distributions. Tellier (1993) suggests that the size of a city is a function of the size of other cities. Theoretically, this statistical regularity observed by the cities of the world has been formalized in laws: Auerbach (1913), Goodrich (1926), and Singer (1936); Zipf Law (1949); Law of the proportional effect of Gibrat (1931); Moriconi-Ebrard Metropolitan Law (1998); These laws have been the subject of theoretical and empirical developments (Beckmann, 1958; Pred, 1977; Pumain, 1982; Guérin Pace, 1990). The most popular model called rank-size is awarded to Georges-Kingsley Zipf.

It was the work of Auerbach (1913), Goodrich (1926), and Singer (1936) that brought to light, for the first time, the existence of a rank-size relationship of cities, followed by the work of Lotka (1941) and Zipf (1949). The name of the latter is associated with a statistical law according to which the distribution of large cities according to their size follows a Pareto law.

However, the research of size distribution of cities has occurred repeatedly in the current topic of urban research (Beckmann and Mcpherson, 2006; Bergs, 2018; Boskeret al., 2008; Jing et al., 2018, Xiangdong Sun 2021, Guanghua Wan 2020). So, a lot of countries have given attention to the analysis and research of city-size distribution pattern (Li and Nam, 2017).

The analysis of spatial phenomena, according to their size, reveals the existence of an order, and a continuity which permits them to be classified according to a relative hierarchy. If we examine the distribution of socio-economic and even natural phenomena, a natural phenomenon according to size, a certain number of invariants can be observed which are reproduced invariants that are reproduceable almost everywhere in any hierarchical distribution (A. Belhedi, 1992). Moreover, from the most isolated hamlet to the village, and from the latter to the city, there is a statistical continuum of localities in space in a more or less constant way; these points are linked to each other by size and number. The law of the size of units according to their hierarchical rank will allow us to see how the agglomerations are arranged and whether they are ranked in a regular way according to their size.

Although it is convenient to consider the world's population as distributed in a series of discrete and isolated groupings, it must be accepted that this conception is somewhat artificial (P Haggett, 1973). The city is effectively a demographic threshold, as there are relatively a few large cities, many medium-sized cities and an infinite number of small cities; as one moves down the hierarchy, the size of the localities decreases but their number increases; it is a pyramid shape.

In Algeria the circumstances and conditions in which urbanization took place and the way that urban growth took place will mark the urban system in its appearance, its hierarchy and its current and subsequent configuration. Urbanization has always been a function of the economic context of the period in question. It has often been triggered by historical or economic events, but its intensity has often remained of the same magnitude.

The history of urban events in Algeria is quite original in that it does not appear as a uniform phenomenon which has developed over time. On the contrary, the history of urbanization in Algeria is made up of a series of successions and ruptures corresponding to the multiple occupations of the country from antiquity to the present day (C. Rahmani, 1982).

In this paper we focus on how urban residents are distributed and agglomerated across different-sized cities in Constantine. This question can be addressed by studying urban system or Zipf's law. It is considered as a tool for comparing inequalities in size between cities. It provides a synthetic description of the territorial organization and allows comparison with a distribution that could be described as ideal on the theoretical level.

LITERATURE : ZIPF'S LAW

However, the various controversies to which it has been subjected, the 'rank-size' law is frequently used to study the evolution of urban hierarchies (Alperovich, 1992; Moriconi-Ebrard, 1993; Brakman et al. 1999; Gabaix, 1999; Dobkins and Ioannides, 2000; Duranton, 2002; Ioannides and Overman, 2003; Gabaix and Ioannides, 2004; so, 2005; Dimou and Schaffar, 2007; Dimou et al., 2008,...)

Zipf (1949) formulated an inverse relationship between the size of a city and its rank. The larger the cities, the smaller their number. His law is based on the assumption that cities are part of a hierarchical system in which each city is more or less related to the others39

According to the rank-size law, since the population of a city is related to its rank, the size of the largest city in a given space determines the size of the other cities. Thus, a city of size 2 has half the population of the rank 1 city, a city of size 3 has a third of the population of the rank 1 city and so on. This can then be expressed in the following mathematical relationship: Pn = P1/n: that is, the population P of rank n is equal to that of the largest city P1 divided by n. The rank-size law is written

LogP = aLogR + b, where:

P: is the population of a city

R: its rank

a and b are constants. They vary greatly depending on the urban system.

a: is the slope of the curve and represents a sort of index of the urban hierarchy, theoretically it should be close to 1.

b: represents the population of the largest city (when R = 1; LogR = 0)

METHODOLOGY OF APPROACH

In order to provide elements of a response to the problematic posed in this article, we have relied on academic works relating to our object of study with a view to identifying and understanding the processes characterising territorial development. This review of the literature was then extended by the analysis of statistical data provided essentially by the National Statistics Office (ONS) and by the various administrations and State bodies subject to our investigation.

Study Area

The wilaya of Constantine, the nodal point of Eastern Algeria, belongs to the domain of the high Constantine plains. It is located between latitude 36° 17 and longitude 6° 37', at an altitude of 800 metres and covers an area of 2,297.20 Km^2.

It opens onto the coast through the wilayas of Skikda (89 km), Annaba (154 km) and Jijel (134 km); and onto the South through the wilaya of Biskra 235 km.

Geographically, it is limited by the willayas of :

- Oum El Bouaghi in the South ;

- Guelma in the East

- Mila in the West;

- Skikda to the North. Fig1

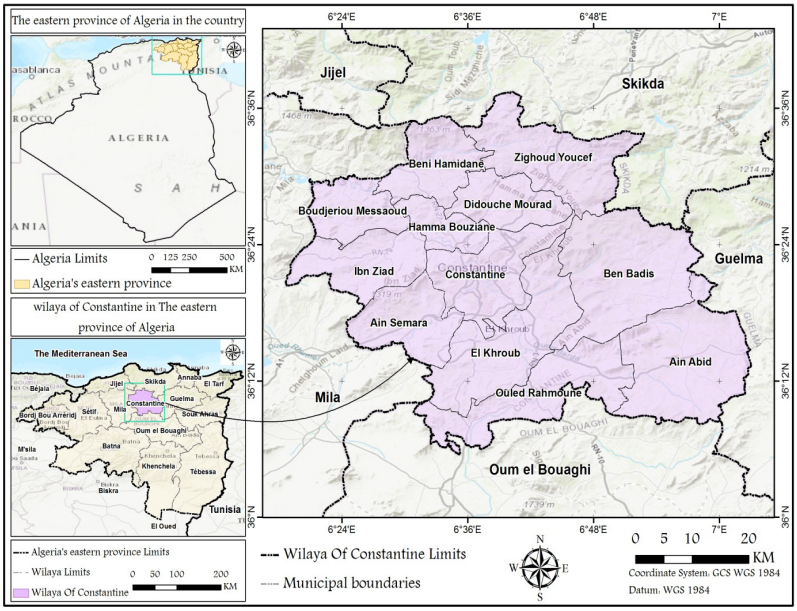


Figure 1. Situation of Constantine (Author)

The State of the Wilaya of Constantine

Constantine was for a long time at the head of a vast territory, since Massinissa chose it as the capital of the Numidian kingdom. During the reign of the Arabs and then of the native dynasties, it suffered from competition, mainly from Massila, then Béjaïa. During the Ottoman period, it definitively regained its status as the capital of the eastern Beylek. It remained so untilthe advent of French colonisation. At independence, in 1962, it was at the head of a vast department. The latter had a dense and fairly well-structured urban framework, made up of large towns and a semi-small and medium-sized towns.

After two administrative divisions in 1974 and 1984, the territory of Constantine had shrunk considerably. Many towns in the urban framework became chief towns of the wilaya. They have thus acquired a large number of important facilities and have become relatively detached from Constantine: such as Skikda, Guelma, Oum El Bouaghi, Khenchela, Mila.

The administrative divisions of 1974 and 1984 have greatly reduced the territory of the wilaya, which has greatly reduced the freedom of manoeuvre that the third largest city in Algeria should have. It has great difficulty in locating the various economic and social programmes.

EVOLUTION OF THE AGGLOMERATIONS IN THE URBAN SYSTEM (1966-2020)

According to table n°1, the first remark is that the urban system of the wilaya of Constantine is articulated around the metropolis of Constantine, which is the historical capital of Eastern Algeria.

It experienced galloping demographic growth between 1966 and 1998, i.e. a gain of 21,900 inhabitants in 32 years. The city of Constantine represented the first urban stratum. Then, it experienced a decrease of 80195 inhabitants between 1998 and 2020, i.e. 22 years, following a transfer of its population to the satellite cities and, initially, to the new city Ali Mendjelli. The number of urban areas has increased to 3 in 2020 in this stratum, which has experienced an average annual population growth rate of 2.17% between 1966 and 2020.

As for the second remark, the absence of the second stratum, that of medium-sized cities with 50,000 to 100,000 inhabitants, was noted for 20 years (between 1966 and 1987) but after this date, this class saw its number increase from

1 to 4 cities between 1998 and 2020 following the shift from small cities to medium-sized cities. This urban stratum has seen a gain of 160,274 inhabitants between 1998 and 2020 in 22 years with a significant growth rate of 9.09%.

The last urban stratum, small towns with a population of between 5,000 and 50,000 inhabitants, experienced a clear increase between 1966 and 2020 with a gain of 8,5803 in 54 years, i.e. an average annual rate of 2.39%. The number of urban units in this category ranges from 3 to 10.

It is observes that the number of urban units in each urban category is unstable during the censal periods following their passage from one category to another.

Table 1. Evolution of the agglomerations in the urban system (1966-2020)

	1966			1977			1987			1998			2008			Pop2020		
	NB	pop	%	NB	pop	%		NB	%	NB	pop	%	nb	NB	%	NB	pop	%
>100000	1	245621	85	1	345566	84	1	441651	77	1	465021	66	2	530916	64	3	941288	73
50 000 - 100 000	0	0	0	0	0	0	0	0	0	1	68038	9.28	1	62655	7,52	4	225513	17.43
20 000 - 50 000	0	0	0	0	0	0	2	66127	11	4	110170	15.66	6	196114	25	2	64701	5
10 000 - 20 000	1	11473	4	2	34814	8	3	38445	7	2	42814	4.46	3	34348	4,12	3	49835	3.85
5000 - 10 000	2	14843	5	1	8612	2	2	15098	2	3	25377	36.08	1	5400	0,64	1	7583	0.58
<5000	9	17106	6	9	23903	6	5	15757	3	2	6114	0,85	1	3022	0,36	1	4816	0.37
total	13	289043	100	13	412895		13	577078	100		717534	10	14	832455	100	14	1293736	100

Source: ONS: general housing and population census

THE HIERARCHICAL ORDERING OF THE URBAN SYSTEM OF THE WILAYA OF CONSTANTINE

There are several varieties of measures that allow the study of hierarchical structure, as well as indicators used in the literature to describe the degree of urban primacy.

The Jefferson index (ratio to the second city), the Stewart index (ratio to the next three cities), or the indicator that evaluates the number of cities whose population is equal to the primary city. The ratio between the population of the first and second cities in the hierarchy allows us to identify the gap or 'drop-out' between the first two cities in the grid. It increases when the main city grows faster than the second city and conversely when the latter catches up with the former.

In conclusion, the instability of the number of agglomerations in each stratum according to the census periods is noted.

Table 2. Evolution of Primacy indices (calculated for Algeria) from 1966 to 2020

city rank	pop 1966	pop 1977	pop 1987	pop 1998	pop2008	pop 2020
1, Constantine	245621	345566	441651	465021	418672	384826
2,Hamma Bouziane	11473	19852	36924	68038	112244	295572
3,Elkhroub	9529	14962	29203	36422	62655	260890
4 Zighoud Youcef	5314	8612	17416	28327	41945	62044
s,t,	271937	388992	525194	597808	635516	1003332
urban pop	289043	412895	577078	717534	746807	1293736
p1/urban pop	85	84	77	66	56	30
Prim 4 = P1+P2+P3+P4/ ΣPop urban	94	94	91	83	85	77
Indice jeffersson P1/P2	21,4	17,4	11,96	6,83	4,61	1,3
Indice stwart P1/p2+p3+p4	9,33	7,95	5,28	3,5	1,93	0,62

Period 1966-1977: The Dominance of Constantine, the Primatial City in the Urban System of the Constantine Region

The city of Constantine is the main primatial city in the urban system, as it stands out from the rest of the urban centres. However, the urban system of the wilaya in this period is strongly polarised. 85% of its population lived in the primatial city, which exerts a high attraction on its hinterland, because of its socio-economic administrative formation. The primacy of Constantine is accompanied by a deficiency of medium-sized towns and a multiplication of small cities.

There is a big divide between the city of Constantine and the second city Elkhroub, which is confirmed by the Jefferson index, which is quite high, 20 in 1966 and 17 in 1977, which explains the gap between the first city and the second.

Thus the stewart index is quite high at 9.33 in 1966 and 7.95 in 1977, which means the gap between the three cities (Elkhroub, Hamma Bouziane,Didouche Mourad) and the main city Constantine.

The factors that can explain the sluggishness of these cities in the urban system of the Constantine region is the strong rurality of these cities.

Period 1987-1998: A Tendency to Stability

The difficult situation of a primary city and the problems of locating housing and equipment programs, results in urban dysfunctions which are very difficult to manage.

The three urban centres of El-Khroub, Aïn S'mara and Didouche Mourad, located within a radius of 15 or 20 kilometres of Constantine, have been solicited for their land potential for an initial postponement of the growth of the Constantine population. This report is essentially demographic of 17512 inhabitants distributed as follows: 2550 inhabitants towards Elkhroub and 5314 inhabitants towards Ain Smara and 7244 towards Didouche Mourad, 6,601 inhabitants towards Hamma Bouziane, 4565 towards Bkira, 11405 inhabitants towards the new city Ali Mendjli during the period (1987-1998).

However the city of Constantine started to lose its demographic weight progressively, it recorded 66% of the urban population in 1987, then 56% in 1998, which is approved by the diminution of the Jefferson index from 11.96 in 1987and 6.83 in 1998 which means that the primatial Constantine is superior to the second city Elkhroub of more than six times, so the diminution of the steward index from 5.28 in 1987 and 3.5 in 1998.

Period 2008-2020: A Real Equilibrium is Established

It is noted that during this period the number of the population of the primacial city has decreased from 56% of the urban population in 2008 to 30% in 2020, as the population growth of the city of Constantine has continued to be transferred to the satellite cities, and has increased from 315,383 inhabitants in 2008 to 103, 1064 inhabitants with an annual growth rate of 9.08%.

However, the biggest part of the transfer was to the new city Ali Mendjeli of 50,000 inhabitants in 2008 where it occupies the second rank after the primatial city in 2020.

As a result, the Jefferson index registered 4.61 in 2008 and 1.3 in 2020, and the Steward index recorded 1.93 in 2008 and 0.62 in 2020.

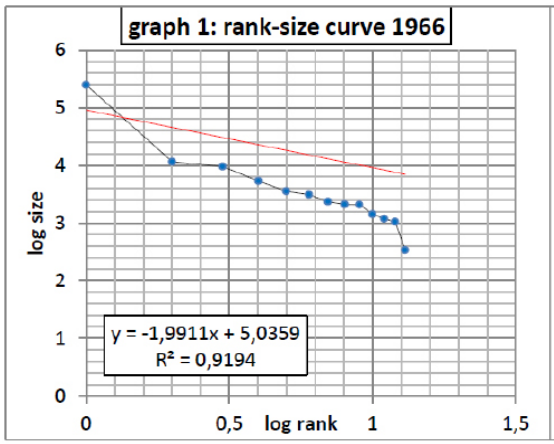
To summarize, the two indices indicate the relationship between the main city Constantine and the cities at the top of the urban hierarchy, whether it is the second city (Ali Mendjeli) or those that follow it in the hierarchy (Elkhroub, Didouche Mourad, Ain Smare).

The report thus highlighted refers rather to the consolidation to the benefit of the primatial city.

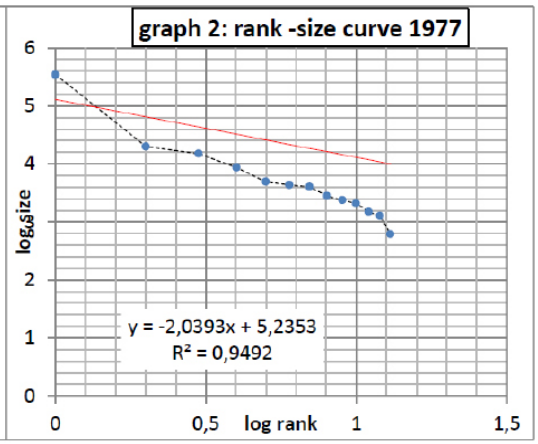
THE URBAN HIERARCHY ACCORDING TO THE SIZE RANK LAW

The most used tool to describe the size distribution of cities is to plot the relationship between city size and rank in a coordinate system.

The analysis of the rank-size graph between different dates allows us to deduce the evolution of the different strata of cities as well as their under- (or over-) representation expressed by the 'breaks' or ruptures which continue over time. In order to better understand the hierarchical process of the wilaya.



Graph 1. Rank size curve 1966



Graph 2. Rank size curve 1977

The graph 1 and 2 shows an disequilibrium of the urban system which is observed from 1966 to 1977, the first city dominates the urban system, which explains the considerable difference between the primary city Constantine of 245621 inhabitants and the second city Hamma Bouziane of 11473 inhabitants.

The city of Constantine deviates considerably above the right of adjustment which indicates an over-representation of the city, which means te real population of 245621 inhabitants is superior to the theoretical population of 90890 inhabitants with a positive residual.

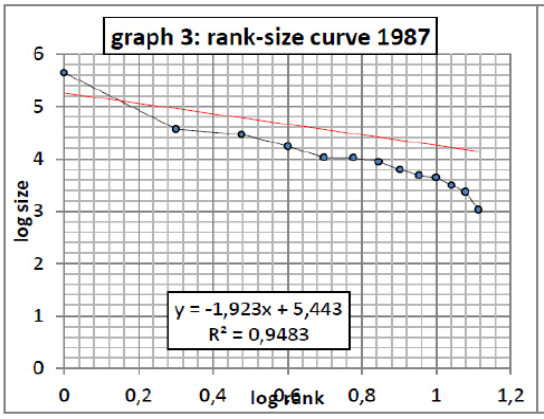
Moreover, it is noted that the descending part of the curve reflects a relative weakness of the small sized centres, which is affirmed by the considerable difference between the real population and the theoretical population.

The theoretical population of these centers is superior to the real population, which explains the recording of negative residues.

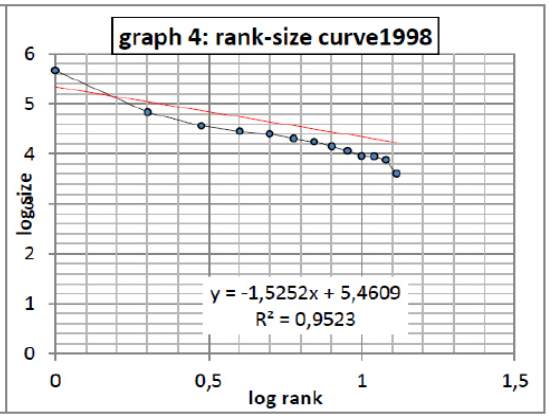
It is beginning in 1987 that the gap between the real population and the theoretical population started to reduce progressively, which is shown in graph 3

The first city is getting closer to the adjustment line but still shows a positive residual.

The hierarchical curve of the cities of the urban system of the wilaya of Constantine shows concavity at the level of all the cities which follow the primatial city, these cities record negative residues. This informs us about the under-representation of the cities, as it is noted that from the year 1998 the curve takes a more regular shape to become steep.



Graph 3. Rank size curve 1987



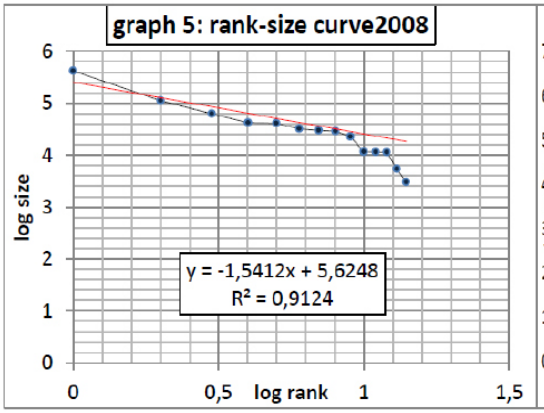
Graph 4. Rank size curve 1998

Graphs 5 and 6 show:

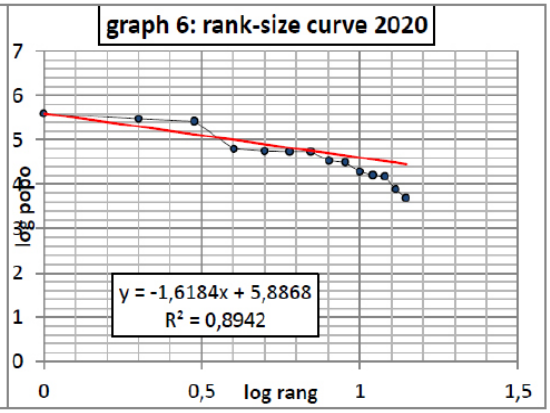
- In 2008, a clearly distinguishable change in the curve was noted, it became more homogeneous, while the localities in the fifth to ninth rank are more in harmony with the right of adjustment, however the curve si convex a the level of the tenth to fourteenth rank.

- In2020, while the primary city regains the right of adjustment. Its real population is less than its theoretical population which explains the register of a negative redus

The curve is slightly convex at the level of the second city Ali Mendjeli of 295572 inhabitants and third Elkhroub of 260890 inhabitants and slightly concave at the level of the fourth city didouche mourad of 62044 inhabitants and fifth city ain smara of 55372 inhabitants.



Graph 5. Rank size curve 2008



Graph 6. Rank size curve 2020

CONCLUSION

The result of this study showed a well distinguished transformation of the urban system of the wilaya of Constantine, the hierarchy of the urban system knew two different situations before the year 1987 and after this year.

It is noticed by a metropolis of unbridled primacy, before 1987 the urban system corresponds to a macrocephaly system, however the urban system is characterized by the domination of the city of Constantine on the cities of immediately inferior rank during 40 years, by its status of regional capital the city concentrates on various equipment and activities at the regional level, of this fact it had accommodated important masses of the population of exodus, consequently the city knew a saturation in all the fields then it became unable to absorb the demographic surplus.

Moreover, the urban system of the wilaya only started to undergo a change from 1987 following the policy of postponing the growth of the city of Constantine towards the satellite cities which are the localities situated in the metropolitan areas, because of the incapacity to solve the problems of housing and equipment.

This is why a rebalancing of the system is recorded, resulting in the appearance of a number of medium-sized cities of 20,000 to 50,000 inhabitants and a city of 50,000 to 100,000 people, in 2008 a trend towards balance was recorded. The urban system has reached equilibrium and the cities of the system are in harmony with the right of adjustment.

However, several questions remain at this stage of the study. Indeed, it would be enriching, in the systemic analysis carried out, to go beyond the sole demographic and a-spatial perspective of the structure of the urban system of the region. Such an approach would also make it possible to determine the effects of spatial dependencies in the development process. What spatial and functional links exist between the cities in this region? In what sense and with what intensity do these links influence the development of the cities?

All these questions, which have far-reaching implications, remain unanswered, but nevertheless open the way to interesting research.

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