

## ANALYSIS AND ASSESSMENT OF URBAN HIERARCHY BASED ON POPULATION. CASE STUDY: THE IRANIAN CITIES

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**Abstract** - Urban system is the special manifestation of political economy and the land management method of a country. The manner of distribution and the level of balance of the cities' population get clearer by examining the urban system. The urban system of Iran tended to change from the traditional pattern before 1921 because of the centralization of facilities and services in big cities. This pattern distracted the logical relationships among small, medium and big cities and led to disorder in the urban system. The research purpose is to assess the Iranian urban hierarchy based on population during the period of 1956-2012. To measure the urban hierarchy, the Entropy coefficient, the rank-size rule, the primate city- Lorenz curve and Gini coefficient were employed. The statistical data cover all cities of Iran in six census periods. The findings of the current study show that the urban system is becoming more balanced with regard to the indices of concentration coefficient, rank-size, primate city, and entropy index; but with regard to Gini Coefficient and population distribution in urban classes, there has been an imbalance compared to the situation in 1956. In fact, according to the Lorenz curve, the Iranian cities have been near the normal line in 1956 but got away from this line in 2012. This is because of the increase in number of small cities with little population and the increase in population of big cities. To reach a balance in urban system of Iran, strategies to decentralize metropolises and boost small and medium-sized cities are suggested.

**Keywords:** urban system, urban hierarchy, urbanization, rank-size rule, Lorenz curve

### INTRODUCTION

Urbanization is a global phenomenon which is occurring rapidly in many less developed countries. It is expected that most urban growth occurs in Asian countries related to two main factors, unplanned rural to urban migrations and natural increase of population (excess of births over deaths). Rapid urban growth is responsible for many socio-economic and environmental changes. Its effects are strongly related to the global issues (Asgharpour and Zanjani, 2013). Over the past two centuries a major change has been taking place in the distribution of the world population in the form of increasing concentrations of people in highly urbanized areas known as urban agglomerations. During the twentieth century, the population of urban agglomerations grew to levels unprecedented in human history. The trend toward ever greater urbanization is continuing unabated across the globe. According to the United Nations, by 2025 close to 5 billion people will live in urbanized areas. Many cities, especially in the developing world, are set to explode in size (UN-Habitat 2010). Naturally, there is an active debate on whether restricting the growth of mega-cities is desirable, and whether it can make residents of those cities and their countries better off.

Cities, as complex and at the same time dynamic systems, have an increasingly important role in the development of economic, social, cultural and spatial structure of a country (Izadi, 1994). Although urban centers in each country are classified quantitatively and qualitatively due to geographical conditions and economic, social and political dimensions (Beikmohammadi, 1996), urban hierarchy is one of the best ways to organize space (Abedin Darkoosh, 2003). Put briefly, urban hierarchy can be defined as the classification of the cities of an urban network based on their importance (Farid, 1996). In recent decades, urban centers have expanded rapidly into metropolises

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(Nazarian, 1995). In 1970 (only) 37 percent of the world's population lived in cities while in 1995 (25 years later), this figure rose to 45%, and ten years later in 2005, the urban population of the world exceeded 50% (Masika & et, 1997). Not surprisingly, the world's urban population is expected to exceed 61% in 2025 (Nazarian, 2001). At the outset of the Industrial Revolution and the subsequent rapid expansion of cities, urban communities have faced much more difficulties. The most significant of these problems are the intense concentration of people and activities in one or more cities along with the failure of urban hierarchy systems in most countries (Amy & Mark, 2005). Planners in most developing countries are dissatisfied with the spatial development of settlements and the regional distribution of population and economic activities therein (Zebardast, 2004). In fact, in most countries, migration from villages and small towns to the big cities and the growing focus on one or more cities is the main cause of failure in the urban hierarchy (Radstrom, BED, 2005). This is reflected in the concentration of population in large cities. This concentration in major metropolitan centers often causes a rebound effect, and the cities around will be empty of capital, goods and raw materials (Rondinelli, 1983).

One of the most obvious characteristics of urbanization in developing countries is the poor spatial distribution. Due to several reasons, the spatial distribution of cities in Iran (which is considered one of the developing countries also) does not follow any order, and imbalance is its main characteristic. In fact, urbanization in Iran is not based on any hierarchical order, and cities, especially large ones, have grown with great many differences from small towns (Rakhshani Nasab and Beik Mohammadi, 2008). Especially in the last half a century, the development of capitalism in form of an oil-export-reliant economy has reduced the importance of agriculture and contributed to the rapid urban growth, and thus led to migration from the countryside to cities (Nazarian, 2000). Since the late 1970s onward, this country witnessed a more rapid growth of urbanization and urban population. Moreover, the transformation of a number of villages into cities and the physical development of cities and incorporating their surrounding villages contribute to a higher urban population (Rahnamaee and Shah-Hosseini, 2004). Accordingly, the overall pattern of spatial distribution of population and urban centers in the country is an indication of funding of and paying attention to urbanization, and especially the tendency to settle in large cities, which will bring about an uneven urban network (Zarrabi and Rakhshani Nasab, 2006). It seems that the Iranian urban networks do not follow any hierarchy and continue to be evolving in terms of centralization.

### **URBAN HIERARCHY**

Every city has its own role and importance. During historical times, cities were established based on geographical factors, such as topography and climate, close to water sources, military factors- the creation of industry and mines, the existence of fertile plains and lands, religious factors and cultural ones. Nowadays the urban population increased and there are problems with the city network hierarchy (Askar, 2011). The urban hierarchy ranks each city based on the size of population residing within the nationally defined statistical urban area. Because urban population depends on how governments define their metropolitan areas, urban hierarchies are conventionally ranked at the national level; however, the ranking can be extended globally to include all cities. The "city network hierarchy" means that regional cities are important. The city hierarchy system was based on central places (Taylor, 2010). In the city hierarchy system, every city competes with numbers and adetermined variety of activities and there is usually a direct relation between numbers and the variety of activities and the city population.

### **STUDY AREA**

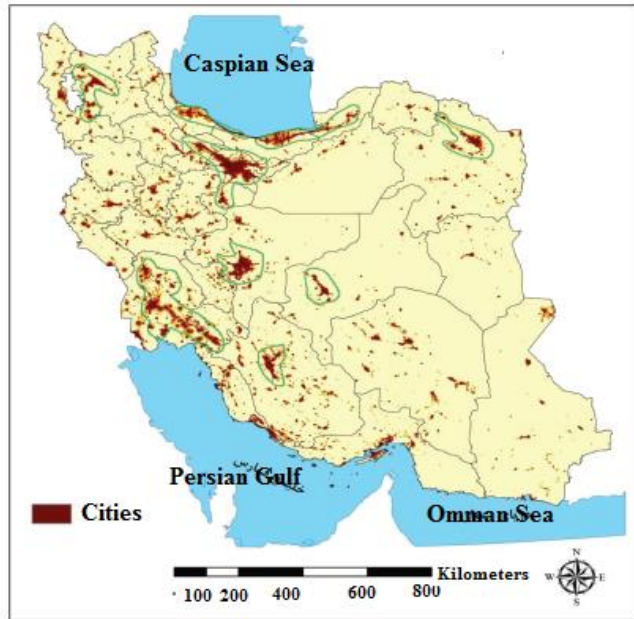
Iran is known as one the oldest civilization in the world and a home to some of the oldest cities such as Shoush from the Elam era (2700 B.C), Hegmataneh from the Median Empire (670 B.C), Pasargad and Takht-e- Jamshid from the Achaemenid (550 B.C) and Neishabour from the Sassanid (224 to 650 A.D.) dynasty. All these Old Iranian cities were well developed as the origins of urban planning and urban settlement during the ancient time (Rasoolimanesh et al 2013). Iran is located in West Asia and borders the Caspian Sea, Persian Gulf, and Gulf of Oman. Its mountains have helped to

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shape both the political and the economic history of the country for several centuries. The mountains enclose several broad basins, on which major agricultural and urban settlements are located. Iran's population in 2016 reached 80 million people. There are 1148 cities and more than 70 percent of the population lives in cities, especially in the big cities. The topography of Iran consists of rugged, mountainous rims surrounding high interior basins. The main mountain chain is the Zagros Mountains, a series of parallel ridges interspersed with plains that bisect the country from northwest to southeast. 7% of the country is forested. The most extensive forests are found on the mountain slopes rising from the Caspian Sea.



**Figure 1.** Location of Iran in the world



**Figure 2.** The spatial distribution of Iran cities

### RESEARCH METHODOLOGY

The research method is descriptive-analytical, involving collecting data in libraries and document research, calendars, article and Iranian statistics center. In this research, we tried to study the hierarchy system of Iran cities based on 1956, 1966, 1976, 1986, 1996, 2006 and 2012 censuses using models: entropy coefficient, rank- size rule, Two-city index, Four-city or Ginsberg index, Mehta Index (MI), Lorenz curve, Gini Coefficient.

### RESULTS AND DISCUSSION

#### Entropy Coefficient

This rule is a criterion to show a balance in a distribution. A higher quantity shows a trend to balance. The form of this model is as the following equation:

$$H = \sum_{i=1}^n P_i \ln P_i$$

$$G = \frac{H}{\ln K}$$

Where H is total frequency in Napierian logarithm,  $P_i$  is the ratio of i-th city population to the total cities population, G is entropy amount and K is number of categories. H was calculated in the years 1956, 1966, 1976, 1986, 1996, 2006, 2012 respectively as:

**Table 1.** The calculation of Entropy coefficient changes in the Iranian urban system (1956-1986)

1986				1976				1966				1956				Years
pilnpi	lnpi	pi	n	Pi.lnpi	lnpi	pi	n	Pi.lnpi	lnpi	pi	n	Pi.lnpi	lnpi	pi	n	Urban classification
-0.30	-1.7	.17	85	-.19	-2.63	.07	27	-.21	-2.43	.088	24	-.24	-2.24	.11	19	0-4999
-0.34	-1.4	.23	117	-.36	-.98	.37	140	-.36	-.84	.432	118	-.37	-1	.37	66	5000-9999
-0.36	-1.2	.30	150	-.34	-1.37	.25	95	-.35	-1.29	.275	75	-.36	-1.18	.31	55	10000-24999
-0.25	-2.1	.12	61	-.30	-1.73	.17	66	-.24	-2.24	.106	29	-.25	-2.14	.12	21	25000-49999
-0.21	-2.4	.09	45	-.17	-2.79	.06	23	-.15	-2.97	.051	14	-.15	-2.99	.05	9	50000-99999
-0.14	-3.0	.04	24	-.12	-3.28	.03	14	-.09	-3.66	.026	7	-.11	-3.4	.03	6	100000-249999
-0.06	-4.2	.01	7	-.04	-4.54	.01	4	-.07	-4	.018	5	-.05	-4.49	.01	2	250000-499999
-0.04	-4.6	.01	5	-.03	-4.82	.008	3	0	0	0	0	0	0	0	0	500000-999999
-0.02	-5.5	.00	2	-.01	-5.92	.003	1	-.02	-5.61	.004	1	-.03	-5.19	.01	1	1000000 and more
-1.75	-	1	496	-1.61	-	-	373	-1.51	-	1	272	-1.56	-	1	179	Σ

Source: Author

$$G_{1956} = \frac{H}{LNk} = \frac{1.56}{2.19} = 0.71 \quad G_{1966} = \frac{1.51}{2.19} = 0.68 \quad G_{1976} = \frac{1.61}{2.19} = .73 \quad G_{1986} = \frac{1.75}{2.19} = 0.79$$

**Table 2.** The calculation of Entropy coefficient changes in urban system of Iran (1996-2012)

2012				2006				1996				Years
Pi.lnpi	lnpi	pi	n	Pi.ln pi	lnpi	pi	n	Pi.lnpi	lnpi	pi	n	Urban classification
-.37	-1.12	.33	371	-.365	-1.13	.32	327	-.28	-1.9	.15	90	0-4999
-.34	-1.41	.24	277	-.34	-1.45	.23	236	-.34	-1.4	.25	150	5000-9999
-.32	-1.64	.19	221	-.32	-1.59	.023	205	-.35	-1.3	.27	164	10000-24999
-.22	-2.4	.09	103	-.22	-2.31	.09	100	-.28	-1.8	.15	92	25000-49999
-.19	-2.64	.07	81	-.18	-2.67	.06	70	-.23	-2.3	.1	59	50000-99999
-.15	-2.9	.05	57	-.14	-3.00	.04	50	-.16	-2.8	.06	35	100000-249999
-.06	-4.3	.01	15	-.05	-4.43	.012	12	-.08	-3.8	.02	13	250000-499999
-.03	-5.25	.01	6	-.03	-5.12	.006	6	-.03	-5.0	.01	4	500000-999999
-.03	-4.96	.10	8	-.03	-5.12	.006	6	-.04	-4.8	.01	5	1000000 and more
-1.7	-	1	1139	-1.70	-	1	1012	-1.81	-	1	612	Σ

Source: Author

$$G_{1996} = \frac{1.81}{2.19} = 0.82 \quad G_{2006} = \frac{1.70}{2.19} = 0.77 \quad G_{2012} = \frac{1.7}{2.19} = 0.77$$

According to the model, if the entropy coefficient approaches zero, it indicates more centralization and a lack of balance in population distribution. If it approaches one, it indicates a balanced regional distribution. The entropy coefficient for the years 1956, 1966, 1976, 1986, 1996, 2006 and 2012 was calculated as 0.71, 0.68, 0.73, 0.79, 0.82, 0.77 and 0.77 respectively. These values show that the Iranian urban hierarchy is going to an unbalanced situation and the population distribution is not balanced between the Iranian cities. In fact, the Iranian urban system comprises many small cities, while the population is concentrated in just a few large cities.

### Rank-Size Zipf's Rule

The rank-size rule is the oldest one that describes the urban system. It is proposed by a German geographer, Felix Auerbach. Auerbach explained that one can arrange settlements based on population. The city population equals to  $\frac{1}{n}$  in the ranking (Jacobs, 2006).

$$P_r = \frac{P_1}{r^q}$$

Where  $P_r$  is the r-the city population,  $P_1$  is the primate city population,  $r$  is the r-th city rank,  $q$  is constant coefficient which is calculated as following equation:

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$$q = \frac{\text{Log } \frac{P_1}{P_r}}{\text{Log } r}$$

According to Auerbach's theory, there is a reversed relation between the rank and the size of cities. This rule was studied by other researchers such as Lotka, Goodrich, Singer. Eventually, G.K. Zipf described a logarithmic mathematical relation as:  $\text{Log } P_r = \log P_1 - q \log r$ .

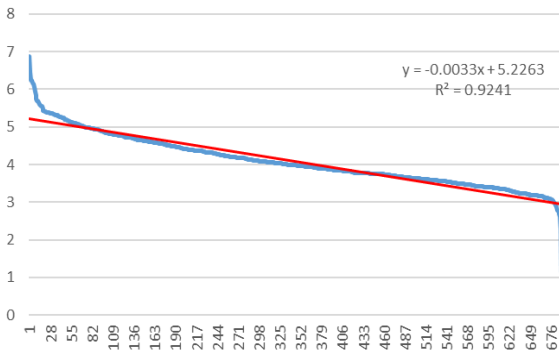
The second phase of interest began with Zipf's restatement of the relationship between population and rank as  $p_r = K r^{-q}$ , the rank-size distribution, going beyond Jefferson's (1939) proposed "law of the primate city" (Stewart, 1947; Zipf, 1941, 1949). In the special case where the exponent  $q = 1$ , this is known as Zipf's Law;  $p_r = K/r = p_1/r$ . Most researchers during this second phase valued the Zipf model ( $\log p_r = \log K - q \log r$ ) rather than the Pareto-form equation, but the relationship between the two is straightforward, and simple algebraic manipulation shows that  $q = 1/\alpha$ . As  $\alpha \rightarrow \text{inf}$ ,  $q \rightarrow 0$ , and all cities are equal size. If  $\alpha = q = 1.0$ , Zipf's Law holds strictly.

Zipf and Stewart precipitated a rush of subsequent literature (e.g. Berry, 1961, 1964, 1971) that concluded with an ambitious cross-national analysis undertaken by Rosen and Resnick (1980), a comprehensive literature review by Carroll (1982), and several papers by Alperovich (1984, 1988, 1989). Rosen and Resnick estimated Pareto coefficients for 44 countries in the 1970s. Three quarters of the cases had a coefficients greater than unity and therefore had urban populations more evenly distributed than predicted by Zipf's Law. This finding was shown to be sensitive to data definitions: Pareto coefficients were closer to unity when the observations conformed more closely to integrated urban-economic regions rather than to legally-defined entities, a point to which we will return later since it has been overlooked by many of the more recent contributors to the field. They concluded that the Pareto distribution was the best general description of rank-size data. Despite their rich empirical findings, Rosen and Resnick ended their investigation with a plea, however. The empirical work lacked one crucial element, they said: a rigorous theoretical model explaining the size distribution of cities. By "theory", true to their training as economists, they meant an intuitively appealing causal story that stands on an axiomatic foundation. This question of theoretical explanation also was at the heart of Carroll's literature review. After examining the body of empirical work to see whether any clear choices of theoretical perspective were indicated, he concluded that there were not (Carroll, 1982, p. 37). It seems that at this point, he said, we do not need new models but instead some basis upon which to rule out several of the existing ones.

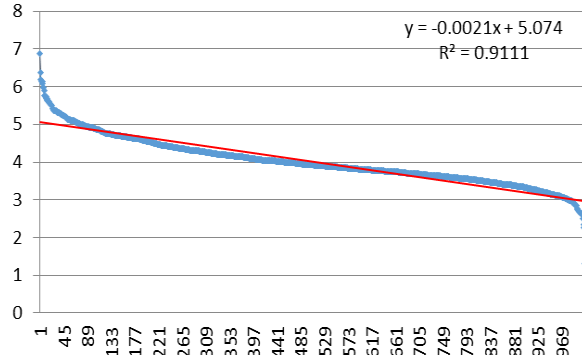
**Table 3.** Equation line slope urban system of Iran (1956-2012)

<b>R2</b>	<b>Equation line slope</b>	<b>Year</b>
0.8199	.0068x+4.7809	1956
0.8202	-0.0054x+4.8454	1966
0.8041	-0.0038x+4.865	1976
0.8853	-0.0037x+5.1139	1986
0.9011	-0.003x+5.1717	1996
0.9111	-0.0021x+5.074	2006
0.9241	-0.0033x+5.2263	2012

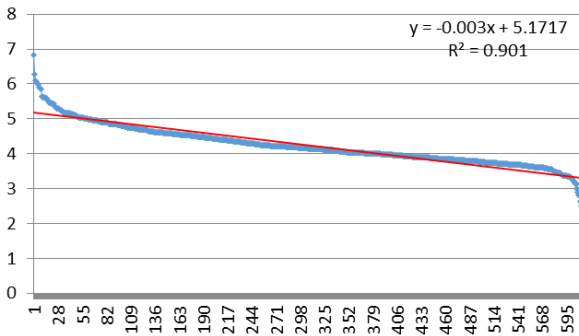
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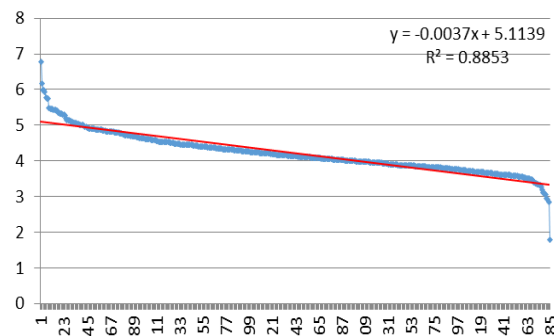
**Figure 3.** The chart logarithm distribution rank-size of Iran cities in 2012



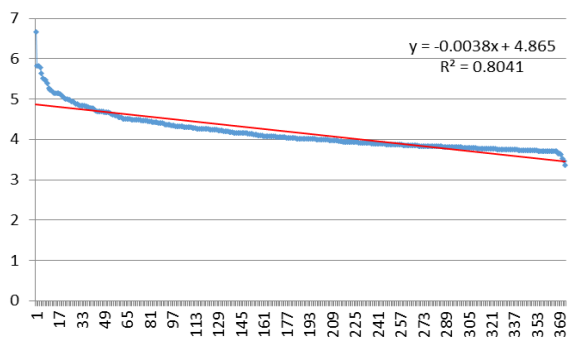
**Figure 4.** The chart logarithm distribution rank-size of Iran cities in 2006



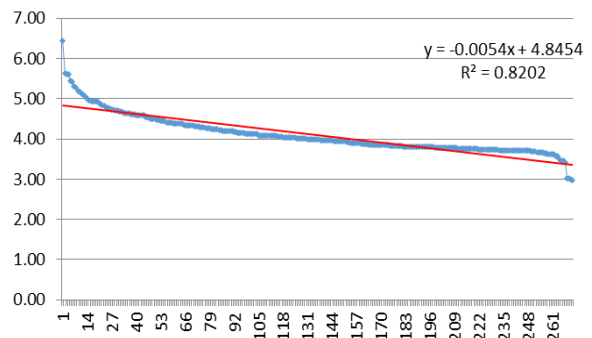
**Figure 5.** The chart logarithm distribution rank-size of Iran cities in 1996



**Figure 6.** The chart logarithm distribution rank-size of Iran cities in 1986

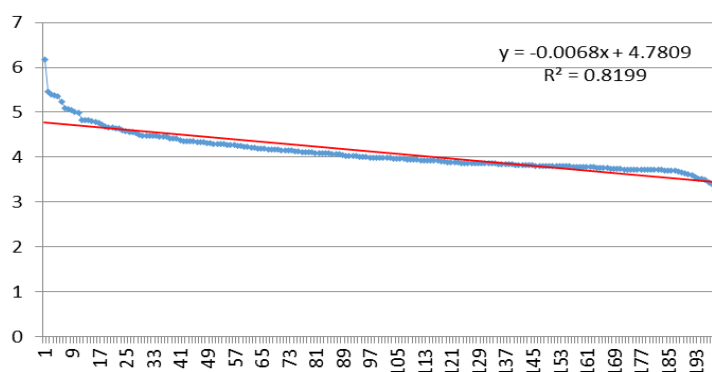


**Figure 7.** The chart logarithm distribution rank-size of Iran cities in 1976



**Figure 8.** The chart logarithm distribution rank-size of Iran cities in 1966

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**Figure 9.** The chart logarithm distribution rank-size of Iran cities in 1956

Also, as shown in Figures 1, 2, 3, 4, 5, 6, 7, differences between real distribution and normal distribution is decreasing in 1966 and 1976 and is increasing in 1986, 2006 and 2012. This is a result of the successful politics of the government to protect the middle cities development for keeping and absorbing population.

**Primate city indicators**

This indicator was first introduced by Mark Jefferson in 1939 in a seminal and innovative paper entitled "Primate City". A primate city is the leading city in its country or region, disproportionately larger than any others in the urban hierarchy. Since this dominant city attracts the most economic and cultural resources of a country, it is introduced as a parasite because it prevents the development of other areas of the country (Shekvy, 2008: 485).

**Two-city index**

Jefferson called Two-city index a relative method based on which first city population proportion is calculated over second city. The bigger the index, the more Urban Primacy ratio the city has (Tofghi, 1997).

$$TCI = \frac{P1}{P2}$$

**Table 4.** Two- city index for Iran cities in the period 1956-2012

2012	2006	1996	1986	1976	1966	1956	Year
2.71	3.19	3.58	4.12	6.78	6.41	5.21	Two-city index

Source: Author

**Four-city or Ginsberg index**

Clark suggests that choosing four first cities rather than two cities is a better choice for calculation. Therefore, he suggested four-city term in which first city proportion is calculated over next three cities (four cities in total) as follows (Azimi, 2002):

$$\text{Ginsberg index} = \frac{P1}{P2 + P3 + P4}$$

**Table 5.** Four-city or Ginsberg index for Iran cities in the period 1956-2012

2012	2006	1996	1986	1976	1966	1956	Year
1.16	1.44	1.55	1.76	2.35	2.19	1.92	Four-city or Ginsberg index

Source: Author

**Mehta Index (MI)**

Mehta index is calculated via dividing the primate city population to total population of the 1st to the 4th rank cities (Mehta, 1964).

$$MI = \frac{P1}{P1+P2+P3+P4}$$

If MI sets between 0.65 until 1, the level of the primate city is the most (high superior), if MI sets between 0.54 to 0.65, the level of the primate city is more (superiority), if MI sets between 0.41 to 0.54, the level of the primate city is desired and if MI sets less than 0.41, then the level of the primate city is the least . Amount of MI has been calculated for the years 1956, 1966, 1976, 1986, 1996, 2006, 2012 respectively as:

**Table 6.** Mehta Index (MI) index for Iran cities in the period 1956-2012

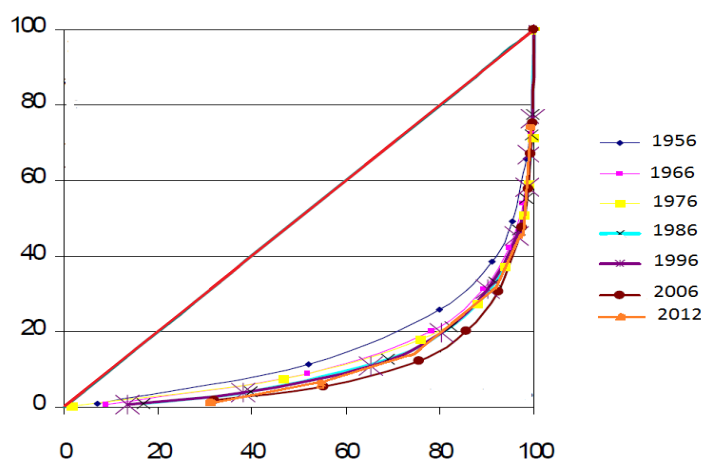
2012	2006	1996	1986	1976	1966	1956	Year
0.55	0.58	0.60	0.63	0.70	0.68	0.65	Mehta Index

Source: Author

As the above table shows in all the censuses in this period, by using primate city indicators, there has been a large primate city in Iran, which results in facilities and population centralization in Tehran and other large cities.

**Lorenz curve**

It would be useful to study the extent of concentration of population by means of Lorenz curve. This graphical measure involves plotting cumulative percentages of population of provinces against the cumulative percentages of the area of the cities. This has been done after arranging the cities in the ascending order in terms of density and calculating the percentages of population (xi) and area (yi) of each city.



**Figure 10.** The chart of Lorenz curve for Iran cities in the period 1956-2012

Source: Author

**The Gini Coefficient**

The Gini coefficient is calculated based on the discrepancy between the diagonal line and the Lorenz curve, dividing that figure by the total of wealth held within a particular country. This allows multiple economies to be compared to one another when examining wealth distribution among individual nations.



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**Table 7.** *The Gini coefficient applied to Iran cities between 1956 and 2012*

2012	2006	1996	1986	1976	1966	1956	Year
0.78	0.80	0.76	0.76	0.73	0.72	0.67	Gini

Source: Author

In Iran, as in other developing countries, not only the urban hierarchy is irregular and disrupted, but also the difference in urban population distribution is also irregular and out of the acceptable balance in urban areas of the country. This irregularity indicates severe centralization in central cities of provinces and metropolitan cities.

As it can be seen from the above table and figures, urban population distribution has no balanced structure in the hierarchy of cities and in both enumerations there is a higher centralization in metropolises of more than 1 million people. Also the Lorenz curve, which shows the graphical representation of this imbalance, indicates this fact (figure 10) which has been set on the basis of the percentage of urban classes and urban population (Table 2). It shows that there is a very concave Lorenz curve in studied course and the difference can be seen in distancing from the uniform distribution line. The mentioned diagram identifies that population distribution in urban areas was not ideal and there was no ideal and positive change in the four last censuses. Moreover, the Lorenz curve is far from the uniform distribution line.

### CONCLUSION AND RECOMMENDATION

Nowadays the significant concentration of population, facilities and comprehensive sources in the capital of Iran and some other metropolises such as Mashhad, Isfahan, Tabriz, Shiraz and some other large cities has made the country facing huge problems like many third world countries. For this reason, the urban system concept can be studied in several directions. One of them is how the population is distributed in many cities of the country and the quality of communications and interactions of these points in the urban network and the spatial organization and balance. The urban network is not only a collection of physical elements and means of communication. It also determines the role and importance of each residence in a system and big cities attract and concentrate more resources and dominate smaller cities. Such processes lead to the reproduction of dominating cities and the functional weakening of smaller places. The continuity of this condition results in forming imbalances in city spatial distribution and the outbreak of problems caused by congestion and high density in cities and the discharge of other places. The charts regarding the logarithm rank-size distribution of Iranian cities show that differences between real distribution and Normal Distribution is decreasing in the years 1966, 1976 and is increasing from the years 1986, 2006, 2012. Entropy coefficient values show that the Iranian urban hierarchy is going to a no balanced situation and the population distribution is not balanced between of Iranian cities. In fact in the Iranian urban system there are many small cities, while the population is concentrated in few large cities. Primate city indicators show in all periods that there have been primate cities in Iran, as facilities and population concentrated in Tehran and big cities. The Lorenz curve identifies that finding population in urban areas was not ideal and there was no ideal and positive change in four last censuses. Moreover, Lorenz curve is far from the uniform distribution line. The recommendations are:

- Reinforcement of small and middle cities in Iran
- Control of big cities growth and decentralization from the cities
- Creation of new towns in big cities periphery
- Prevention of villager migration to big cities
- Business creation in villages and small cities
- Decentralization of industrial and administrative power of Tehran
- Reinforcement facilities and services in small cities

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