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ARAŞTIRMA MAKALESİ / RESEARCH ARTICLE

OPTIMAL SIZE OF TURKIYE'S GROWING CITY: TEKİRDAĞ

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Abstract

Migration from rural areas to cities is increasing day by day as cities offer more opportunities in terms of education, employment and health. According to 2022 TURKSTAT data, around 68% of the population in Turkiye resides in cities. Total urban population worldwide is expected to reach 4.9 billion by 2030 and 68% of the world population to live in cities by 2050 (PRB, 2007 & UN, 2017). Hence, it is predicted that uncontrolled population growth, especially in cities, will render resources insufficient and necessitates optimal city size measurements for sustainable development. In this study, the optimal city size is examined for Tekirdağ, as one of the cities in Turkiye that is exposed to irregular migration inflows and having the highest population growth rate in the recent years. This study applies the happiness degree model to estimate the optimal city size for Tekirdağ utilizing several resource indicators for the years 2018 and 2021. It is argued that the resources of the city will be depleted and therefore the happiness level of the residents will decline should this trend continues. According to 2022 statistics, it is concluded that the city is observed to be overpopulated for Tekirdağ, which has a population of over one million.

Keywords: Optimum Population, Happiness Degree Model, Tekirdağ
Jel Codes: C10, J10, R10

1. Introduction

The optimal size of a city is the marginal size when there are inefficiencies in city governance or when a city loses its appeal to citizens (Choi, 2017). Urban populations are increasing day by day as individuals living in rural areas are moving to cities for reasons such as higher job opportunities and better living conditions. According to UnHabitat World Cities Report (2022), while the urban share of the population has doubled from 25% in 1950 to about 50% in 2020, it is projected to increase to 58% over the next 50 years. However, due to the ever-increasing urban population, resources of the cities are depleted and hence are expected to become inadequate for the residents. Many cities continue to experience population growth that far outstrips the ability and resources of local authorities to expand infrastructure coverage and provide adequate health services. Increased traffic, rising energy costs, high levels of waste and pollution, and rising carbon emissions threaten the sustainability of cities in the new century.

The size of a city is essential not only to represent the scale of the urban system, but also to support prosperity, order and rapid development (Feng et al., 2021). To remain sustainable, cities

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need to improve their infrastructure, take measures to minimize the environmental impact of dense populations, create new employment opportunities and develop projects that focus on growth and development. This is why the concept of a 'technologically connected city', or the Internet of Things (IoT) using big data, is being promoted to achieve efficiency and intelligence in the management of urban resources.

There are several empirical papers in which the optimal city size is calculated using different indicator in economic, social and environmental terms. Li et al. (2018) estimate the impact of changes in city population and industrial structure on CO_2 emissions. The study analyzes 50 cities with different population sizes according to various indicators between 2005 and 2014. Kong (2022) addresses the impact of prefecture level city financial development on urbanization and conducts an empirical study using the correlation between financial development level and city size. Castells-Quintana et al. (2020) examines the relationship between city size and income inequality for 153 functional urban areas in OECD countries. Frick and Rodriguez-Pose (2018) analyze whether there are certain city sizes that increase growth for 113 countries between 1980 and 2010 and how additional factors highlighted in the literature affect the relationship between city size and growth with an econometric model. Jie and Yang (2017) conduct an empirical analysis on the relationship between city size and city energy consumption efficiency based on the energy consumption data of 286 cities. Lianos and Pseiridis (2016) focus on the question of what the maximum population of 50 countries should be based on ecological footprint and biocapacity data to estimate a sustainable level of prosperity.

In this study, optimal city size is examined for Tekirdağ, one of the cities in Turkiye with the fastest population growth in recent years that provides living space 1.14 million people in 2022 (TURKSTAT, Provincial Indicators, 2022). It has the status of a metropolis receiving migration due to its proximity to another metropolis with developed business, infrastructure, energy, water and environmental facilities, Istanbul, located in the eastern border. Therefore, it is of great importance that the population size of Tekirdağ, which is a center of attraction mainly due to its location and being a developing city, increases in a conditional on ensuring the optimal use of resources and not depleting them. Following the methodology of Shi et al. (2010), this paper aims to estimate the optimal population for Tekirdağ using the happiness level of the residents that is dependent on the consumption of the resources. Several indicators reflecting economic, infrastructural, social and environmental dimensions are utilized for the recent and available years, 2018 and 2021, for a more robust analysis over the years.

The paper is organized as follows. Section 2 introduces the theoretical model. Section 3 presents the findings for the case study. Section 4 concludes the paper.

2. Theoretical Model

Urban optimum population is determined by the resources and services provided by infrastructure, economy, society, resources, environment and household subsystems (Shi et al., 2010). With the idea that individuals who make good use of these subsystems offered by cities achieve a high level of happiness. The theoretical model uses a basic utility function (*U*) of a representative agent defined as the happiness degree (*h*) which is determined by the level of consumption (*c*).

$$h = U(c) \tag{1}$$

The optimal city size is based on maximizing the product of individual happiness *U*(*c*) and population *N*, and the degree of urban happiness of households is denoted by *H*.

$$H = N\ x\ U(c) \tag{2}$$

When the equation is rewritten by expressing the consumption level of a person (c) as the ratio of the total amount of resources (*T*) to the population (*N*), the following expression is obtained.

$$H = N\ x\ U\left(\frac{T}{N}\right) \tag{3}$$

To maximize the utility, i.e., the total degree of happiness, the first derivation of the above function should be taken and set equal to zero. Then, by replacing $\frac{T}{N_S}$ by c_s, the problem of finding the optimum population is reduced to finding the per capita consumption. In this case, the following equation is obtained.

$$\frac{T}{N_S} = \frac{U'\left(\frac{T}{N_S}\right)}{U\left(\frac{T}{N_S}\right)} = c_S = \frac{U'(c_S)}{U(c_S)} \tag{4}$$

According to the rule of diminishing marginal utility, *U* will increase with the population when the population is low, while it will increase at a decreasing rate when the population is high. Given that *a* and *β* be positive parameters, where *β* is the least upper boundary of *U* and (1+*a*) is the elasticity of marginal happiness, the following equation is proposed:

$$U(c) = \beta - \frac{1}{c^{\alpha}} \tag{5}$$

After proving that the first derivative of *U*(*c*) is greater than zero and the second derivative is less than zero, in other words, that the degree of happiness function is consistent with the rule of diminishing marginal utility, the optimal consumption level per person c_s can be induced as follows:

$$c_S = \frac{\left(\beta - \frac{1}{c_S{}^{\alpha}}\right)'}{\left(\beta - \frac{1}{c_S{}^{\alpha}}\right)} \Longrightarrow \sqrt[\alpha]{\frac{\alpha+1}{\beta}} \tag{6}$$

A standard of living where the level of happiness is zero is defined as $U(c_0) = 0$, where (c_0) is defined as the population that the amount of resources the city can support. The coordinate for $(c_0,0)$ is easily determined on the function. *U(c)* Defining a second point for (c_t) as $(c_t 90\%$ $\beta)$ brings the target consumption level at the optimal level of utility, the equation is set up as follows:

$$U(c_0) = \beta - \frac{1}{c_0^{\alpha}} = 0$$
$$U(c_t) = \beta - \frac{1}{c_t^{\alpha}} = 90\%\beta \tag{7}$$

The parameters *a* and *β* are obtained as follows:

$$\alpha = log_{\frac{c_t}{c_0}} 10$$
$$\beta = \frac{1}{c_0^{\alpha}} \tag{8}$$

Following these calculations, the happiness degree function can be obtained and the optimal consumption level can be calculated. Given the level of resources, the optimal population can be calculated using the below calculation.

$$N_s = \frac{T}{c_s} \tag{9}$$

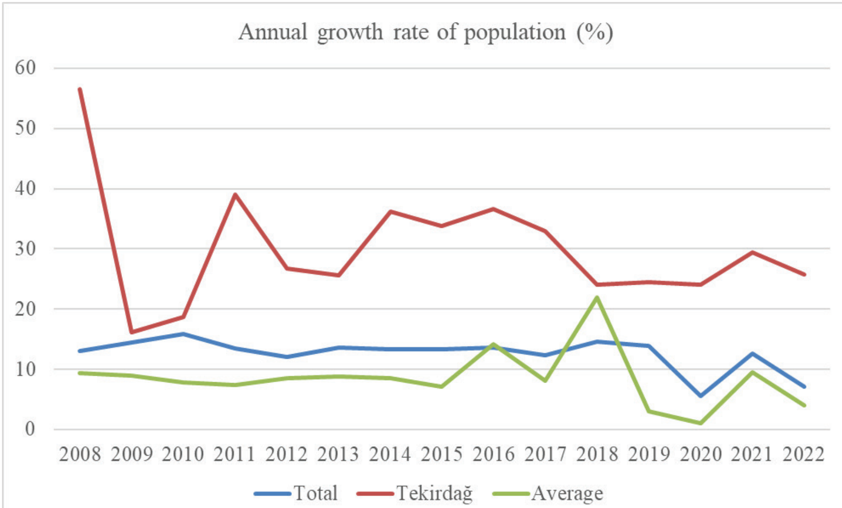
Lastly, Shi et al. (2010) states that the optimal population out of the optimal populations based on different resources will be determined by selecting the minimum one. This procedure is also followed in the empirical part of this analysis.

3. Case Study

The theoretical model estimates the optimal city size for Tekirdağ, which is the 20th largest city in Turkiye according to the population size constituting around 1.34% of the overall population of 85,279,553 (TURKSTAT, 2022). However, Tekirdağ ranks first in terms of the population growth out of the cities with population size larger than 1 million[1]. Figure 1 depicts the annual population growth rates of Tekirdağ, Turkiye and the average of all 81 cities of Turkiye. The graph reflects that Tekirdağ's population growth rate is clearly above overall and average over the time horizon of 2008-2022 with an average of 30%.

1 Population grew by 1.98% from 2000 to 2022 and by 1.08% from 2018 to 2021. The latter time period is chosen regarding the data availability of the indicators used as resources in the model. Out of the whole 81 countries, Tekirdağ ranks second following Yalova with a population of 296,333 by 2022.

Figure 1: Comparison of Annual Population Growth Rates



Considering the utility function explained in the theoretical framework, this study estimates the optimal population for Tekirdağ using several dimensions. For 2018, the economic dimension is defined by the gross national product per capita (dollar) indicator, represented as ***GDP***; the social dimension is represented as ***TNT*** in terms of the number of primary-secondary teachers per student and ***TE*** in terms of the number of enterprises per capita; the utilities dimension is represented as ***EW*** in terms of the total electricity consumption per capita (kWh) and ***AW*** in terms of the amount of drinking water per capita distributed by municipalities through drinking and potable water networks (m^3); the infrastructure dimension is represented as ***AB*** in terms of the building permit area per capita (m^2); and artificial green land per capita represent the environment dimension as ***AGA***. Data were obtained from TSI Official Statistics, Ministry of Agriculture and Forestry Corine report and General Directorate of Highways Official statistics.

For the parameter values of c_0 and c_t, the data of the cities with minimum and maximum values for each indicator among all cities of Turkey are used. The parameter values to be calculated for each indicator using the equations in the model are presented in Table 1.

Table 1: Parameter Values for Resource Indicators in 2018

Dimensions	Indicator	c_0	c_t	T (Unit: Million)	N_s (Unit: Million)
Economic	GDP	2,999	16,627	13,778.36	2.44
Utilities	EW	786	8,325	7,977.81	5.05
	AW	17.85	73.37	46.08	1.43
Social	TNT	0.05	0.10	0.06	0.77
	TE	0.02	0.07	0.05	1.60
Infrastructure	AB	0.57	4.25	3.20	2.86
Environment	AGA	16.88	709.42	308.50	8.38

In the theoretical model, it is stated that the minimum population value out of the whole optimal populations based on several is selected as "optimal out of optimals". Accordingly, the optimal population of Tekirdağ city is calculated as 770,000, indicated by the TNT indicator. Analysis based on the indicators reflect that the optimal population should be 2.44 million according to the economic dimension; 1.43 million according to the utilities dimension; 770,000 according to the social dimension; and 2.86 million according to the infrastructure dimension. Last but not least, it is found that the green areas are sufficiently available given around 8.38 million population that maximizes the happiness of the residents based on the environment dimension.

For 2021, the economic dimension defined with the gross national product per capita (dollar) indicator, represented as ***GDP***; the social dimension is represented as ***TNT*** in terms of the number of primary-secondary teachers per student and ***TE*** in terms of the number of enterprises per capita; the utilities dimension is represented as ***EW*** in terms of the total electricity consumption per capita (kWh); the infrastructure dimension is represented as ***AB*** in terms of the building permit area per capita (m^2) and ***TAR*** in terms of the total asphalt road length per ten thousand inhabitants. The parameter values to be calculated for each indicator using the equations in the model are presented in Table 2.

Table 2: Parameter Values for Resource Indicators in 2021

Dimensions	Indicator	c_0	c_t	*T (Unit:Million)*	N_s *(Unit:Million)*
Economic	GDP	2,988	17,089	16,463.85	2.91
Utilities	EW	944	11,004	8,503.04	4.45
Social	TNT	0.05	0.09	0.06	0.82
	TE	0.02	0.08	0.06	1.63
Infrastructure	AB	0.69	5.32	2.61	1.93
	TAR	0.21	28.76	3.67	7.64

In 2021, the optimal population value given the resources explaining all dimensions for Tekirdağ is 820,000 which is specified by the TNT indicator of the social dimension. Analysis based on the indicators reflect that the optimal population should be 2.91 million according to the economic dimension, 4.45 million according to the utilities dimension and 1.93 million according to the infrastructure dimension.

For each indicator, N_{si} values were calculated by changing the population value between 10,000 and 7,000,000 and index values were standardized between 0 and 100. SH is the standardized value of H, H_{max} and H_{min} represent the maximum and minimum value of H varying with population; H_p is the happiness degree when population is p. Figure 2 and 3 depict the utility function (happiness degree) for Tekirdağ with the standardized values of the degree of happiness for each index where the standard value of happiness degree is given on the y-axis and the varying population values on the x-axis.

$$SH = 100\ x\ \frac{H_p - H_{min}}{H_{max} - H_{min}}$$

Figure 2: Standard Value of Happiness Degree Varies with Urban Population in Tekirdağ for 2018

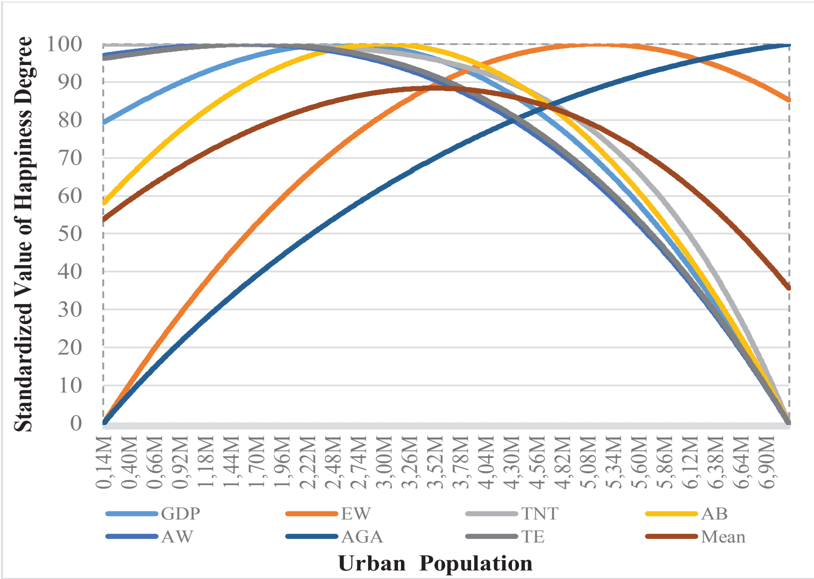
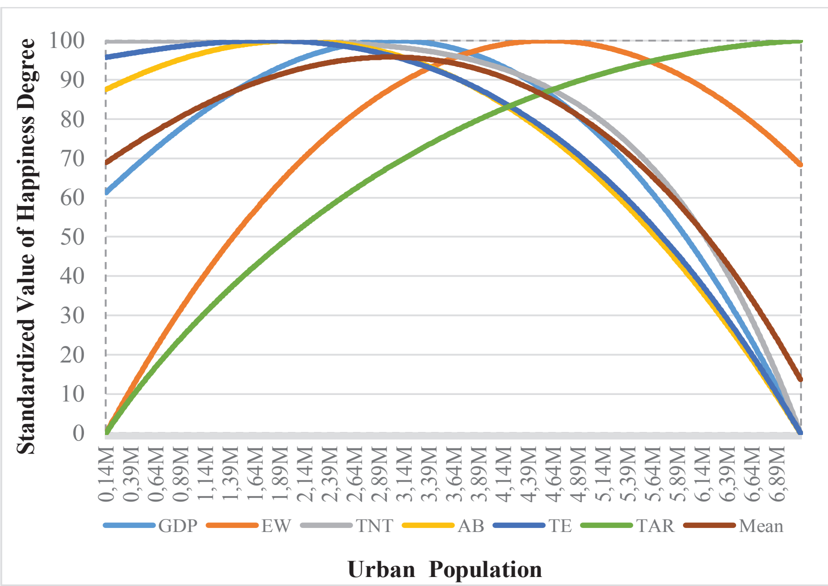


Figure 3: Standard Value of Happiness Degree Varies with Urban Population in Tekirdağ for 2021



4. Discussion and Conclusion

Although large cities offer more job opportunities, infrastructure and superstructure services, and technological competence compared to the small cities, the population balance must be well maintained in order to ensure a sustainable development. Population should not be determined solely on the basis of area size. On the basis of different criteria, the optimal population that the city's resources can support should be taken into consideration since a society with high population density that cannot provide access to resources at an adequate level and fairly distributed will lose its happiness degree, which is a classical theoretical way to describe social welfare.

The aim of this study is to investigate the optimal population for Tekirdağ, as a case study for Turkiye. Happiness degree model is applied for two different years, 2018 and 2021, using various indicators. The findings reflect that the optimal population of Tekirdağ should be between 770,000 and 820,000, successively. The result suggests that the city, which currently has a population of over one million, is overpopulated. Accordingly, it can be argued that the sustainability of the will be disrupted if the trend of growth rate persists. Especially, the index regarding the number of teachers per student (gives the minimum optimal population), which represents the social aspect of the resource indicators, may turn out to be a social issue in the upcoming years considering the increase in the young population of the city. Concludingly, bringing general/local governments and the relevant ministries (especially Ministry of Environment, Urbanization and Climate Change) together to call for an urgent country-wide urbanization policy should be the priority to ensure the long-term social welfare.

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